WIN! ROBOT ARM & FLICK HATS

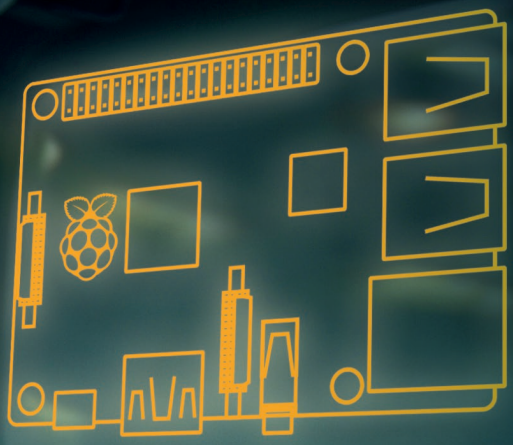
The MagPi

The official Raspberry Pi magazine

Issue 63 November 2017

raspberrypi.org/magpi

BUILD AN ARCADE MACHINE



NERF GUN ROBOT
FRED-209: You have 20 seconds to comply

MAKE A MIDI SOUND BOX
Make your own sound machine

CONTROL LEGO MINDSTORMS
Use LEGO robotics kits with Raspberry Pi

JUNIOR PI PROJECTS
Hacks & makes to inspire your kids

Also inside:

- REVIEWED! MONSTERBORG, PIJUICE AND OLED BONNET
- CLEARING LAND-MINES WITH AN EXPLOSIVE PI ROBOT
- 3D BODY SCANNING WITH 27 PI ZERO W DEVICES
- NEW PI-TOP LAPTOP REVEALED INSIDE

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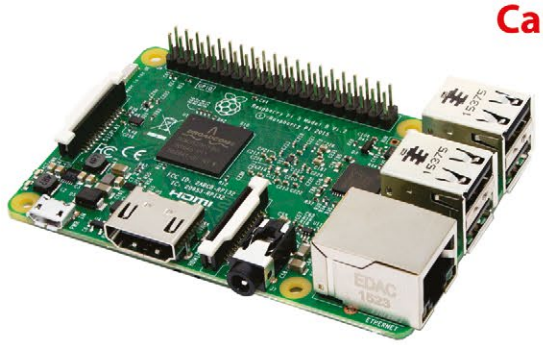

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WELCOME TO THE OFFICIAL MAGAZINE

Hands up who wanted their own arcade machine when young. Everyone, right? This month we feature a full-on, full-size, full-scale, actual honest-to-goodness arcade machine; wooden cabinet, sticks, buttons and all. You'll find it standing tall on page 16.

Now, I could talk all day about how important making is for education; how arcade games are a path for youngsters to coding and electronics. (And we do that in Pi Junior Projects on page 66.) I could also talk about how the new pi-top laptop is transforming education by providing kids with a hackable alternative to shiny tablets (page 6) or how building a MIDI sound synth will inspire kids who love music more than machines and need a reason to learn code (page 42).

Or, how Raspberry Pi is capable of performing real change in the world. Like clearing land-mines (page 36). Or how Raspberry Pi robots like MonsterBorg (reviewed on page 74) are so powerful, and popular, that Rolls-Royce itself is using them to scout for the next generation of engineers (page 8).

But in all truth: this month we just wanted our very own arcade machine.

Lucy Hattersley
Editor - The MagPi

WIN! ROBOT ARM & FLICK HATS
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SUBSCRIBE & SAVE 25%
SEE PAGE 32 FOR DETAILS

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Make a classic arcade cabinet with a Raspberry Pi inside

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Build your own electric synth and make some noise

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Raspberry Pi projects to inspire younger makers

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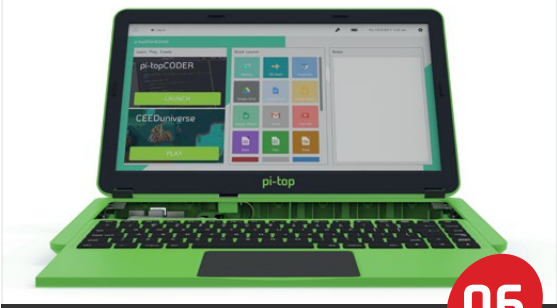

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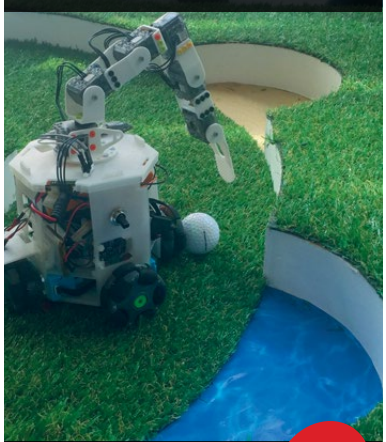

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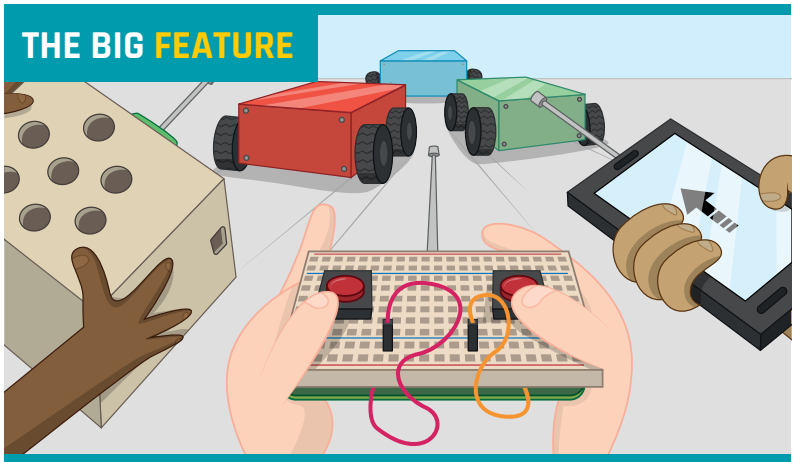

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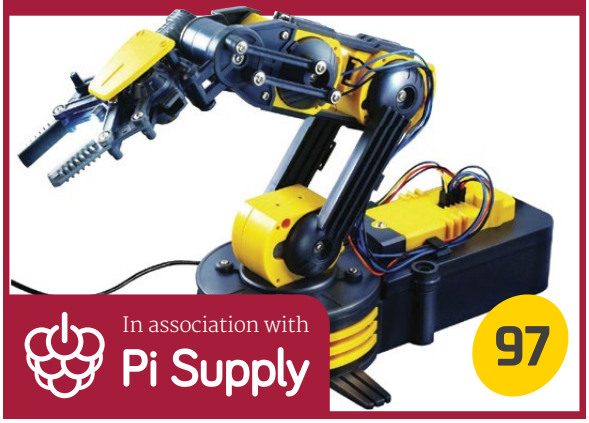

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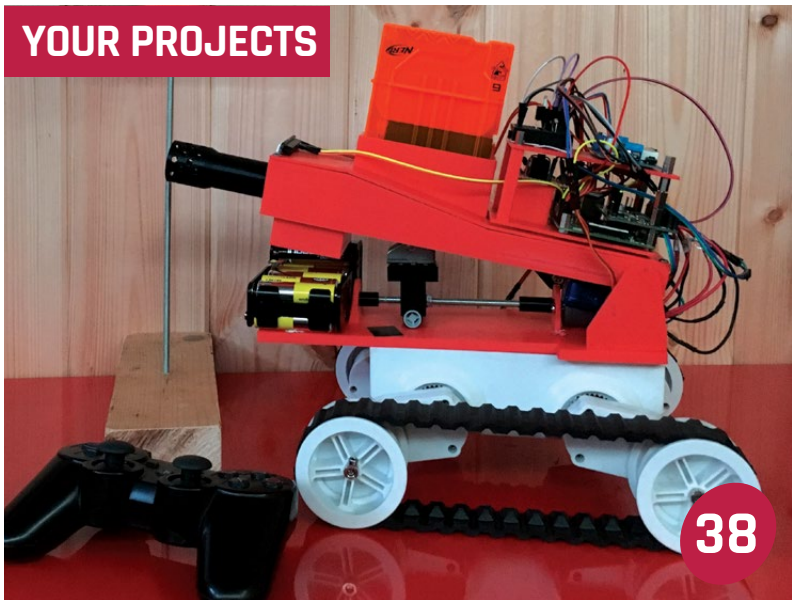

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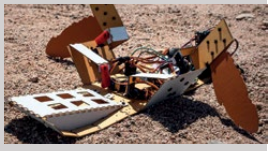

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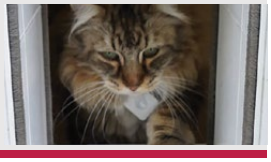

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NEW PI-TOP LAPTOP LAUNCHED

Updated Raspberry Pi laptop with sliding keyboard mechanism

A new version of pi-top, the modular laptop based on a Raspberry Pi, has been revealed. It features a whole new design with an impressive sliding keyboard.

The keyboard is, to our eyes, the most interesting new feature. It's connected via a flexible cable and it slides down to provide access to the Raspberry Pi and other electronic components.

The fresh design enables a larger keyboard with a clickable trackpad now located below, in the typical position for a laptop. It also features a larger 14-inch display and an internal battery providing 8–10 hours of power.

Build quality is said to be improved and we find it a more professional-looking laptop, but one that still offers great potential for hacking and making.

"The first thing you do with pi-top is build it," says Jesse Lozano, CEO of pi-top. Because students understand the internals, they "really focus on what you can build", he tells us.

Raspberry Pi inside

A Raspberry Pi 3 is used as the brains of the laptop. The laptop runs pi-topOS, an operating system based on Raspbian. As well as programs like Scratch and Minecraft Pi, pi-topOS has office apps likes Google Docs and LibreOffice, and Google Drive cloud storage support.

It also comes with dedicated coding tools such as pi-topCODER and CEEDuniverse (an adventure game in which students need to solve visual programming puzzles). It's the only education technology platform endorsed by the UK awarding board OCR (Oxford Cambridge RSA Examinations).

Two magnetic rails are used to quickly connect and remove components to the kit

A Raspberry Pi 3 provides the brains of the laptop, enabling it to run the Raspbian-based pi-topOS with all the software and coding capabilities of a Raspberry Pi

The keyboard slides down, enabling access to the Raspberry Pi and electronic components

Left The new design looks like a typical laptop, but you build it yourself and can add electronic components to the inside

Inventor's Kit

Included with the package is an Inventor's Kit. This contains 20 parts and instructions for electronic projects. We saw a motion-activated robot, wire game, and a music machine built using LEDs and buttons.

The parts are used with the included pi-topPROTO+, a breadboard with GPIO breakout pins. The piTopPROTO+ clips into a hub connected to the Raspberry Pi, and sits on top of the new magnetic sliding module rail. This enables students to quickly add (and remove) components, such as a speaker, to the laptop.

"pi-top's mission is to provide powerful, inspiring products that bring science, technology, engineering, arts and mathematics to life," states Jesse Lozano. "Our newest generation of modular laptops helps achieve that goal. Now, anyone from young musicians to scientists to software developers to inventors can explore and create wonderful new projects using the pi-top laptop. We're offering learning beyond the screen and keyboard, enabling wider exploration of computer science and basic electronics, ensuring that young learners have the opportunity to be inspired by a world of STEAM-based learning."

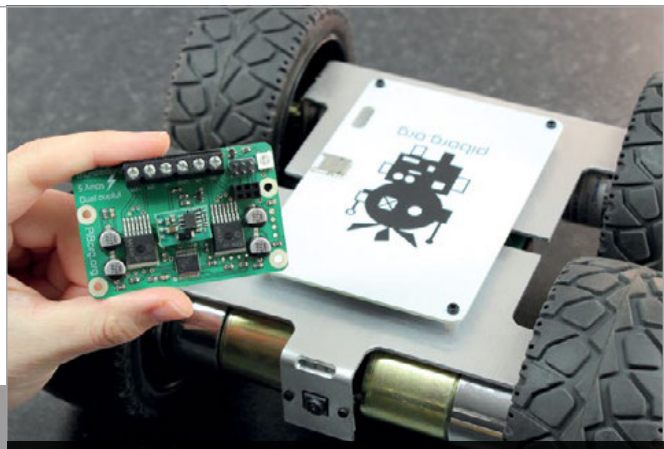
> "Because students understand the internals, they really focus on what you can build"

The new pi-top is available now, direct from the pi-top store (**magpi.cc/2i904QK**), priced at $319.99. It is also available without a Raspberry Pi for $284.99. UK pricing had not been confirmed at the time we went to press, but ModMyPi was listing it for pre-order at £259.99 (**magpi.cc/2i8Bn73**). The laptop kit is also available at The Pi Hut, Adafruit, RS, and other retailers.

Below The pi-top comes with parts and instructions for 20 electronic and maker projects

ROLLS-ROYCE HOOKS UP WITH FORMULA PI

New challenge for robot racers designed to find the next generation of Rolls-Royce engineers



Rolls-Royce's RaceYourCode competition will use the MonsterBorg robots from Formula Pi

Rolls-Royce has hooked up with Formula Pi to create a one-day RaceYourCode event. "RaceYourCode was conceived by Rolls-Royce as a fun, innovative way to challenge the finest digital thinkers and coders around the world," reads the welcome page.

"As a successful applicant, you'll be racing autonomous, Raspberry Pi-powered robots around a track as fast as you possibly can," the competition entry page continues.

Rolls-Royce is looking for the next generation of engineers to work in the famous company.

"Data has been essential to our business for 20 years," says Andrew Hutson-Smith, Director of Business Development and Innovation. "We're looking to find people who are analytically minded but creative," explains Andrew. "It's quite a rare talent, actually."

Rolls-Royce also wants people who can "understand the data," adds Andy Appleyard, Global Resource and Capability Manager, Digital.

> "We'd love to hear from you, regardless of wherever you are in the world..."

It's a quirky competition. Each driver will have control of two MonsterBorg robots, one 'leading' and the other 'trailing', both of which have to cross the start/finish line. These robots are controlled by a Raspberry Pi 3, with a WiFi connection to the internet and to each other. The challenge is that your leading robot can only 'see' the track in front of it and your trailing robot can only 'see' behind it (each via a small on-board camera with limited range).

"The competitors get 45 minutes to look at the code," explains Timothy Freeburn, PiBorg Director. "They can tinker with the code. Then, at the end of it, they get three laps to race the robots around."

Like Formula Pi, the RaceYourCode event will use MonsterBorg robot kits (check out our review of the latest MonsterBorg on page 74).

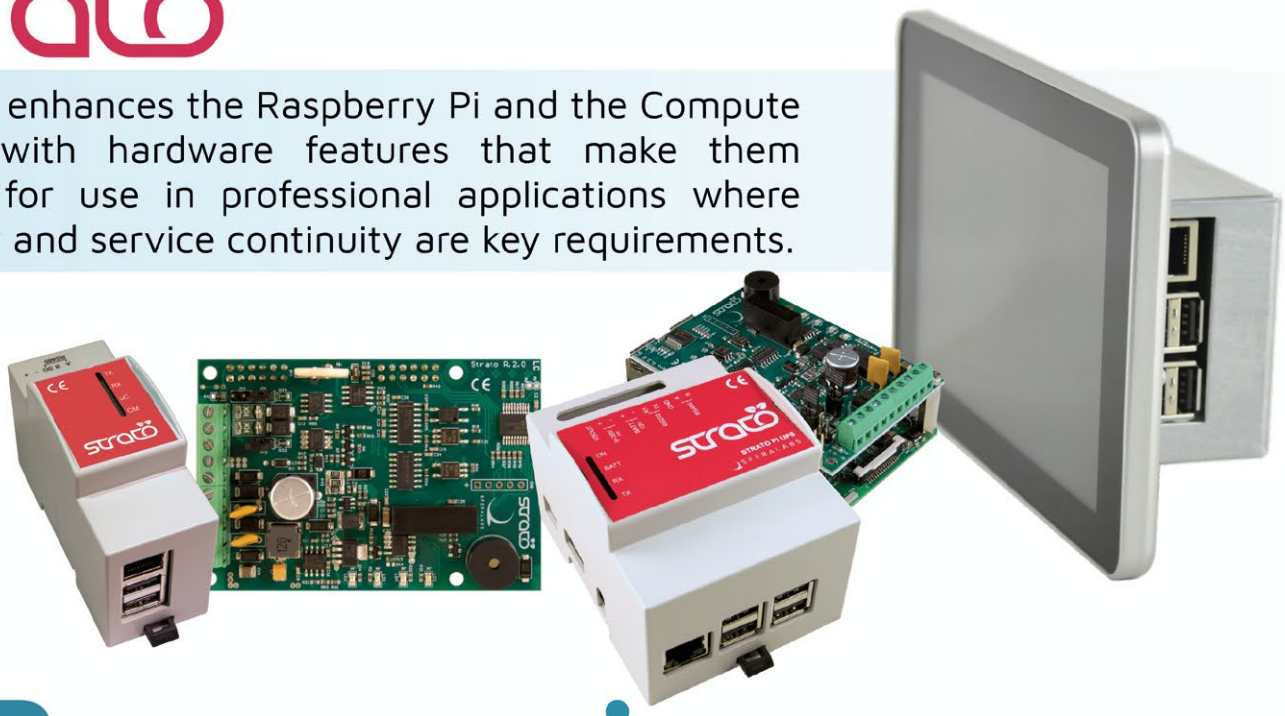
The final races will be on either Monday 11 December or Tuesday 12 December. Full instructions for the event can be found here: **magpi.cc/2icaLlO**.

Folks interested in the RaceYourCode event can sign up at **magpi.cc/2i8GtjH**. "We'd love to hear from you, regardless of wherever you are in the world." says Andrew Hutson-Smith.

Below Entrants will race two robots around a Formula Pi track, one with a camera facing forwards, the other facing backwards

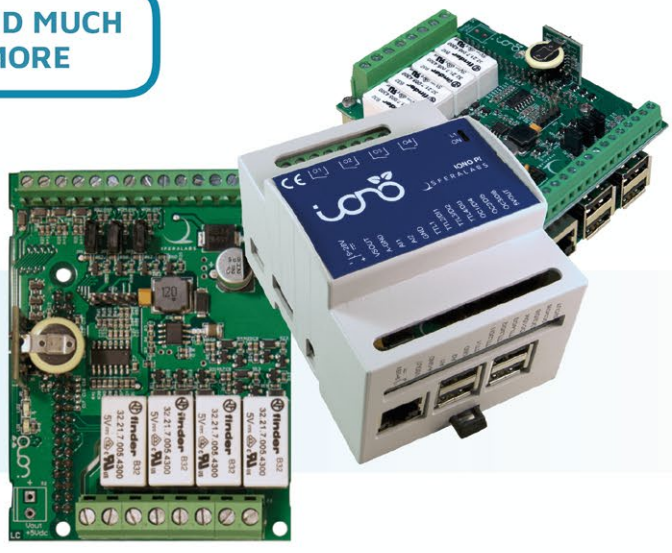
Raspberry Pi for professional applications

Strato Pi enhances the Raspberry Pi and the Compute Module with hardware features that make them suitable for use in professional applications where reliability and service continuity are key requirements.



- CE/ROHS CERTIFIED
- REAL TIME CLOCK
- HARDWARE WATCHDOG
- DIN-RAIL CASE
- CAN BUS
- UPS
- POWER RELAY
- RS-232 / RS-485
- WIDE RANGE POWER SUPPLY
- MODBUS
- .. AND MUCH MORE

Iono Pi is a versatile I/O module that combines digital and analog standard interfaces with the powerful computing core of the Raspberry Pi.



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OVER 100 TEAMS IN PI WARS 2018

New challenges, new rules

The new rules and challenges for Pi Wars 2018 have been revealed, so we caught up with co-founder and co-organiser Mike Horne to see what's new for the next Wars.

Teams entering Pi Wars must build a single robot that can tackle a range of challenges, including an obstacle course, a straight-line speed test, and an event called 'Slightly Deranged Golf'.

Two events from last year – Skittles and Line-Following – have been replaced by the Duck Shoot and Somewhere Over the Rainbow. Mike explains that they decided in their second year to always attempt to have updated challenges so that returning teams "couldn't just bring out the same old robot!"

Duck Shoot pits robots against a line of duck targets, knocking them over by either pushing balls or firing projectiles. Mike tells us, "We're expecting a lot of people will leave this one to the last minute [to design for] – not a good idea!"

Somewhere Over the Rainbow has been introduced based on feedback for a vision-based challenge. The robot must visit the corners of a square arena in order of colour. As always, there's a simple and more complex solution: method 1 randomises the corner colours, so your robot must be able to scan the corners and create a route itself, based on its scans. Method 2 doesn't randomise the colours.

"We expect most Intermediate and Pros to try method 1", Mike confirms. "It's not as complicated as it seems."

New rules

Some returning challenges have updated rules. "The straight-line speed test will have narrowed sections that will test how straight the robots are travelling", Mike reveals, while "the Minimal Maze is being made slightly easier by allowing six temporary targets to be added." The challenge was just too tough last year. The tee area of the Slightly Deranged Golf course will also be lowered, with a smoother slope, to help robots complete the course.

Awards will still be given for artistic and technical merit, as well as blogging skills leading up to the event. Mike says, "We're considering other awards – such as the Funniest Robot, from last year."

You can read the full challenge list and rules for Pi Wars 2018 on the Pi Wars website (**magpi.cc/2hLjyeh**).

High standard

Mike confirmed that more than one hundred teams have applied for 2018's Wars, and that "the quality of the applications, and the amount of detail they've given, is much higher this year." It sounds as if 2018 is going to be fiercely competitive.

Pi Wars 2018 takes place in the William Gates Building of the Cambridge Computer Laboratory, from 21 to 22 April.

TIPS FOR PI WARS 2018

We talked to Pi Wars veteran Brian Corteil to get his take on 2018's design challenges.

Asked whether the new challenges require specific designs, Brian says, "I hear that some people are redesigning their robots ... making their robots smaller to cope better with the minimal maze turns."

"The new Over The Rainbow challenge would benefit from motors with encoders," Brian suggests. "The new motors may require a redesign of the robot's chassis. The Duck Shoot challenge can be covered by a simple add-on."

"Omnidirectional robots seem to be becoming more common," according to Brian, while "another trend I have noticed is that the robots are getting better each year; more reliable and powerful."

"Building your first robot from a kit is a good way to start," Brian confirms, but "avoid kits with trolley wheels" which will struggle with some challenges. Brian advocates using a video game controller to steer your robot, an on-board running mode switch, and plenty of spare batteries.

Robots face many tricky challenges throughout the Pi Wars competition

PI-POWERED TURTLE ROVER

Explore Earth with this rugged rover

Following our interview last month with Kell Ideas' CEO Szymon Dzwonczyk, the Turtle Rover has exceeded its Indiegogo funding target by over €6,000.

Szymon tells us, "Everyone will still be able to buy the Rover via Indiegogo [see **magpi.cc/2hIuGZf**], and by the end of the year from our shop." The kit Rover costs $990 (roughly £750) plus shipping, while a built Rover costs $1,972 (roughly £1,500) plus shipping.

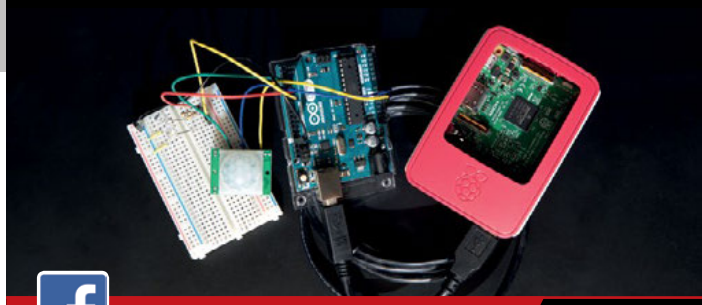
At the heart of the Turtle Rover is a Pi 3. As Szymon explains, "We love the computer and need to encourage people to play with the rover software using open-source code from the Pi community." The bespoke Turtle HAT uses "H-bridges and an STM32 [microcontroller] to drive the robotic arm." The Turtle Rover is rugged, waterproof, and fully customisable, with wireless control (via an app) at up to 200 m. The internal battery should last for 4 hours of driving time.

> "We love the computer and need to encourage people to play with the rover software"

Designed by Mars Rover prototype engineers, the Turtle can do the same job on Earth

NOW TRENDING

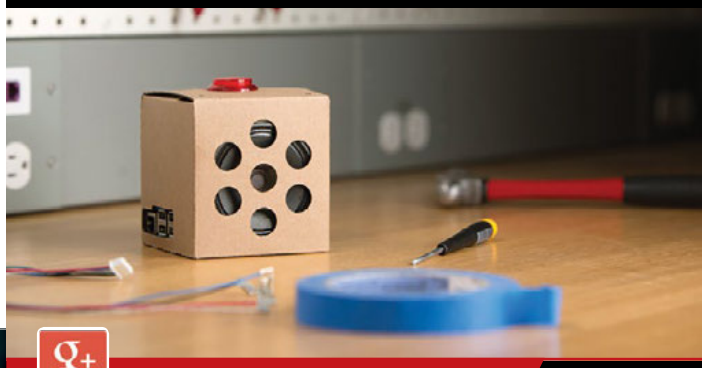
The stories we shared that flew around the world



TWIN YOUR PI WITH AN ARDUINO

magpi.cc/2h8NAVj

A Raspberry Pi might have loads of GPIO pins to interact with sensors and control motors, but for an extra level of finesse and accuracy, you can pair a Pi with an Arduino board.



AIY PROJECTS PRE-ORDER

magpi.cc/2hJeQof

Find out where to pre-order the new AIY Projects Voice Kit with a 76-page Essentials Guide. Here it comes!

PI DECK - PLAY DIGITAL MUSIC LIKE A DJ

magpi.cc/2eSICeA

With a Raspberry Pi inside, these turntables allow Daniel James to scratch and mix digital tracks as if they were on vinyl, but without lugging boxes of records to every gig.

FREE IOT BOOTCAMP WITH EBEN

Practical, hands-on advice from industry leaders, including Raspberry Pi CEO Eben Upton

Above The Adafruit pack to accompany the bootcamp is extensive, but we bet you've got most of the bits already

ADAFRUIT IOT VIRTUAL BOOTCAMP CHECKLIST

- 1 × Raspberry Pi 3 Model B ✓
- 1 × Raspberry Pi 3 case ✓
- 1 × 8GB microSD card with NOOBS 2.0 ✓
- 1 × 5V 2.4A Raspberry Pi power supply ✓
- 1 × Slim HDMI Cable - 450mm / 1.5 feet long ✓
- 1 × Assembled Adafruit Feather HUZZAH ESP8266 WiFi
- 1 × Micro servo
- 1 × PIR (motion) sensor
- 1 × USB cable – A/Micro B
- 1 × Fast vibration switch
- 1 × Magnetic contact switch (door sensor)
- 2 × DHT22 temperature-humidity sensor
- 1 × Full-sized breadboard
- 1 × Male/male jumper wires – 40 × 6″
- 1 × Female/female Jumper Wires – 20 × 3″ (75mm)
- 1 × Female/male Jumper Wires – 20 × 3″ (75mm)
- 1 × Male/male Jumper Wires – 20 × 3″ (75mm)
- 1 × Male/male Jumper Wires – 20 × 6″ (150mm)
- 1 × Assembled Pi Cobbler Plus
- 1 × USB to TTL Serial cable
- 1 × HDMI 7″ 800×480 Display Backpack – with Touchscreen

Electronics:

- 6 × 12mm Tactile switches
- 1 × Breadboard trim potentiometer 10K
- 2 × Diffused 10mm green LED
- 2 × Diffused 10mm red LED
- 1 × Diffused 10mm blue LED
- 1 × Diffused RGB (tri-color) LED
- 10 × 10K 5% ¼ W Resistor
- 10 × 560 Ω 5% ¼ W Resistor
- 1 × Electrolytic capacitor – 1.0 µF
- 1 × Piezo buzzer
- 2 × Photo cell light sensor
- 1 × Breadboard-friendly SPDT slide switch

The Raspberry Pi Foundation, Microsoft, Adafruit, and Hackster.io are pooling resources to deliver a three-day Internet of Things (IoT) Virtual Bootcamp. Since it's virtual, you can attend from anywhere, and the price of attendance is free.

Day two features a Raspberry Pi focus, with a talk from Raspberry Pi co-founder Eben Upton along with hands-on labs based around the Raspberry Pi.

Virtually hands-on

The hands-on labs have been made possible by Adafruit, which has created a pack of hardware and components that will be used by the course leaders (**magpi.cc/2hIjpbd**). This pack includes a Raspberry Pi 3, a touchscreen, and Adafruit's Feather Huzzah ESP8266 WiFi. Limor

> "It's your best chance to learn more about IoT from the experts, and in real time"

As Limor Fried, founder and engineer of Adafruit (better known as 'Lady Ada'), tells us, "The goals of the bootcamp are to enable partners to get started with IoT through simple exercises; provide accessible and scalable IoT technical education; and educate the audience on Enterprise solutions."

Adam Benzion, Hackster.io co-founder, adds, "This IoT bootcamp … will be rich in hands-on labs, code sharing, and live practice. It's your best chance to learn more about IoT from the experts and in real time."

As such, the bootcamp is perfect for anyone considering a commercial IoT product. However, there will be plenty of hands-on demonstrations during the three days for hobbyist makers to learn from.

describes this as "our WiFi-enabled microcontroller, programmable using the Arduino IDE, and one of our easiest platforms to help you break into the IoT world."

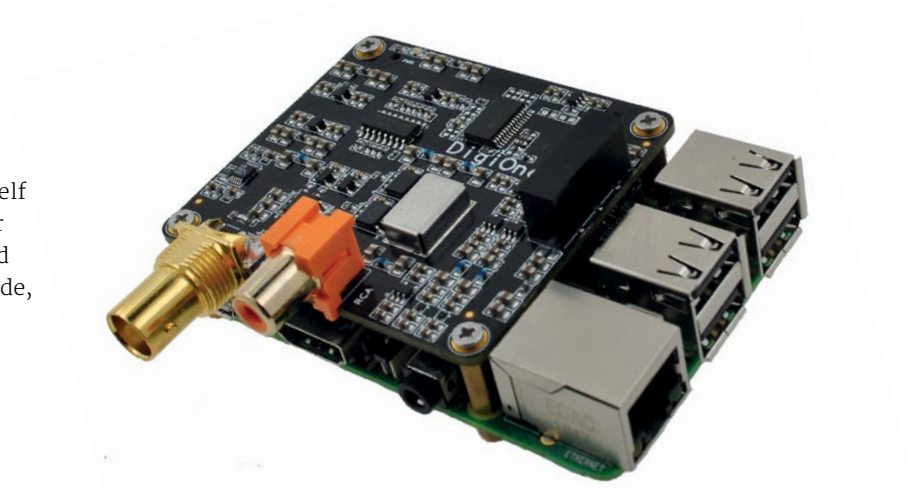
This pack should be available to buy in the UK, as The Pi Hut owner Jamie Mann tells us, "We'll more than likely stock the kit, yes. However, it's currently out of stock at Adafruit."

We've listed all the components, as you may well have most of them already. The Pi Hut (**thepihut.com**) and Pimoroni (**shop.pimoroni.com**) carry a wide range of specific Adafruit parts and packs.

To attend the virtual bootcamp, sign up with Microsoft (**magpi.cc/2hJsrow**).

NEW PI HAT RIVALS TOP-END HI-FI

Raspberry Pi high-end audio streaming device DigiOne



Indian firm Allo is making a name for itself with a series of high-end audio HATs for Raspberry Pi. Following the £55 Boss and £35 MiniBoss DAC HATs is its latest audio upgrade, the DigiOne.

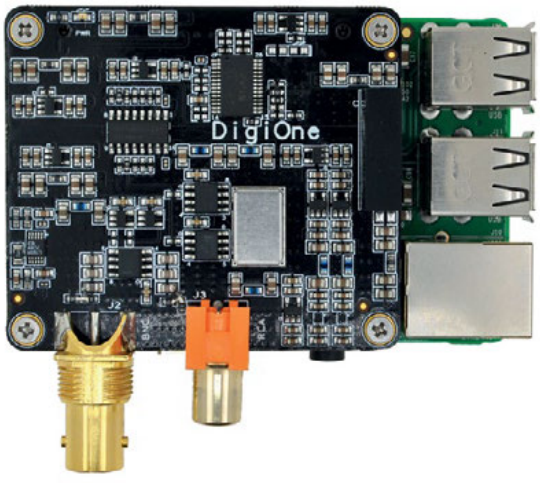
At £95 (from **thepihut.com**), the DigiOne costs almost the same as three Pi 3s, but that's not quite the point, as Allo's CMO Andre Strul explains: "We believe the Raspberry Pi has the potential to become the new audio platform for the streaming generation."

Allo is gunning for the likes of Sonos, in a market where prices of £500 for a single speaker unit are common. That makes a £35 Pi with a £95 audio HAT look like a great deal!

The DigiOne is a 'transport', aiming to circumvent the Pi's audio hardware entirely. Andre explained that the Pi could only produce frequencies of 44.138 kHz or 44.0366 kHz, both of which would cause jitter in 44.1 kHz audio.

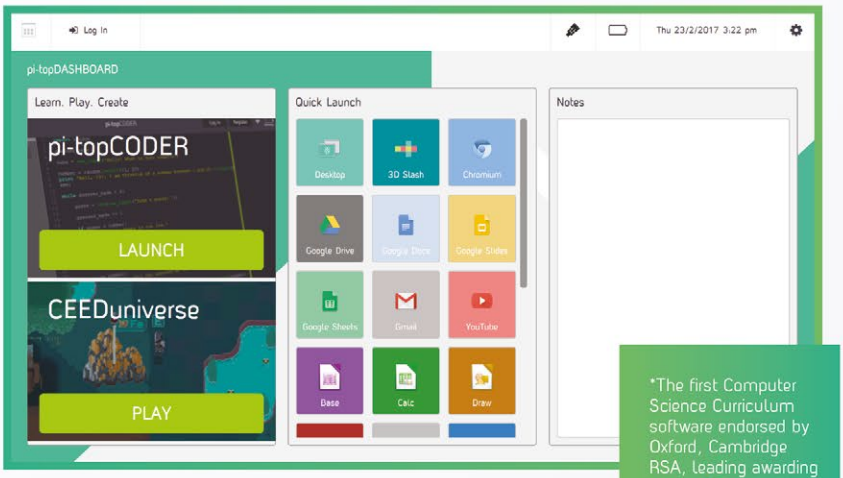
Instead, the DigiOne generates its own clock, and combines that ability with heaps of filtering, noise reduction, and signal realignment to output audio at up to 192 kHz/24-bit, with jitter as low as 0.6 picoseconds and noise of 50 µV.

Allo says reaction to the DigiOne has been "tremendous. We see interest not only from EU and USA, but from countries like Vietnam, Taiwan, and Brazil."

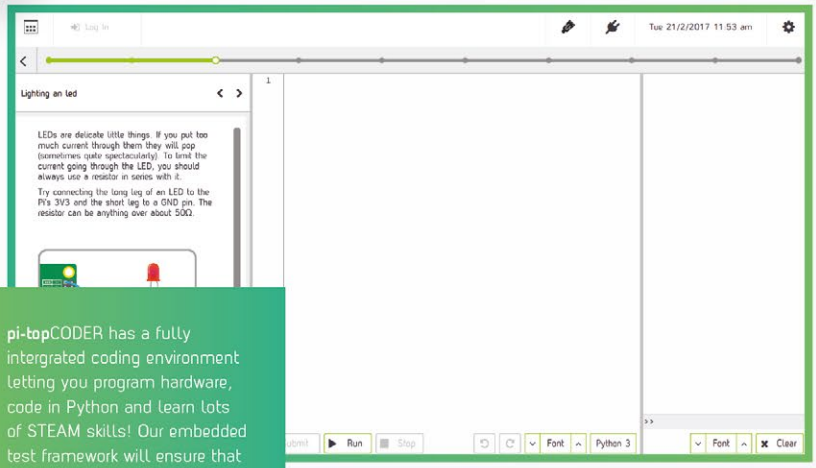


pi-topOS

The OCR* endorsed **pi-top**OS (Operating system) platform comes pre-installed on the 8GB SD card shipped with every unit. **pi-top**OS software suite lets you - browse the web, - check emails, - create and edit Microsoft Office compatible files. It includes **pi-top**CODER and comes with the revolutionary educational game CEED**universe**.



*The first Computer Science Curriculum software endorsed by Oxford, Cambridge RSA, leading awarding body - **OCR**.



pi-topCODER has a fully intergrated coding environment letting you program hardware, code in Python and learn lots of STEAM skills! Our embedded test framework will ensure that you understand all concepts.

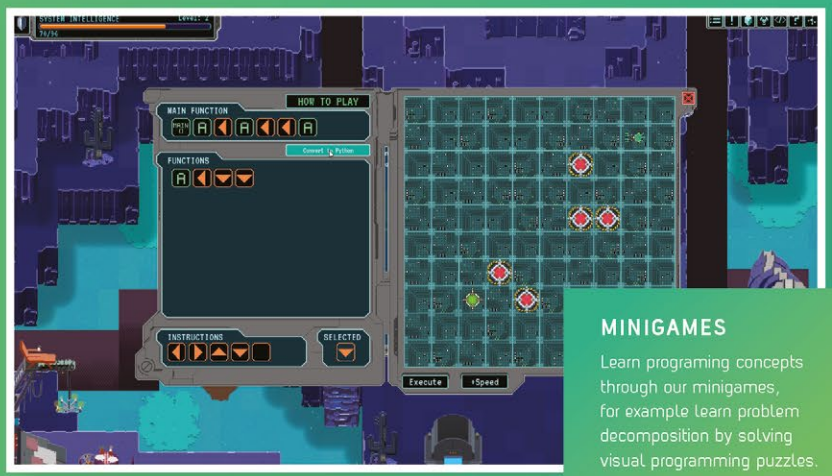
pi-topCODER

pi-topCODER is the interface that allows you to access worksheets and pre-built Raspberry Pi projects. It's the easiest way to tinker or deliver lessons by providing step-by-step guides for computer science and STEAM worksheets.

CEED**universe**

CEEDuniverse is our educational game. It's a world of fantasy developed in line with the computing curriculum – taking science fiction and transforming it science. It is a FREE massive role-play game carefully crafted by **pi-top**. The game teaches students to solve computational puzzles, how to code in Python and build physical circuits which interact with the game.

Exploring the planet, the students first encounter 'drag & drop' coding puzzles and move on to writing text based code.



MINIGAMES

Learn programing concepts through our minigames, for example learn problem decomposition by solving visual programming puzzles.

BT More power to you
CPC
Findel Education Resources The choice for schools for classrooms for specialists
MISCO
RS
ypo

pi-top

WWW.PI-TOP.COM

POWERED BY RASPBERRY PI

LEARN
PLAY
CREATE

pi-topCEED

The modular all-in-one
Raspberry Pi powered desktop

- Adjustable Viewing Angles
- 14" HD Screen
- Modular Components

pi-top

The modular build-it-yourself
Raspberry Pi powered laptop

- 10 Hour Battery Life
- 13.3" HD Screen
- Modular Components

pi-topSPEAKER

NEW

pi-topPULSE

pi-topPROTO

pi-top | Worldwide shipping available in green or grey at www.pi-top.com or our distributors
Stay up to date with our latest news by following our social media

BUILD AN ARCADE MACHINE

Grab some wood, a Raspberry Pi, and some quarters and let's take it back to the Eighties

As kids, many of us dreamed about owning arcade machines when we grew up. Whether they were early classics such as Pac-Man or tournament mainstays like Street Fighter II, the idea of having a little slice of our local arcade just sitting in our living room was extremely appealing.

The reality in 2017 is not great, with arcade machines getting old and maintenance becoming prohibitively expensive. We could talk to you at length about the importance and cost of video game preservation, but instead we're going to show you how to go one better than a grungy X-Men cabinet with dodgy sound, to build your own perfect and brand new arcade emulation machine with Raspberry Pi and a bit of elbow grease. Insert some credit and let's start.

This arcade build was made by Bob Clagett of I Like to Make Stuff iliketomakestuff.com

START

TOOLS FOR THE JOB

All you need to build your dream arcade machine

This is not a small project, so you'll need to have plenty of tools for this job. Bob built this with a lot of precision, although at some steps you can make do with something a little simpler if you don't have the specific tool.

WARNING! Not all these tools are necessary. Read through the build first to figure out what you'll need.

CIRCULAR SAW

DRILL/DRIVER

ROTARY TOOL

JIGSAW

UTILITY KNIFE

SOLDERING IRON

CLAMPS

MEASURING TAPE, STEEL RULER & PROTRACTOR

Get Bob's digital plans for the arcade cabinet online: magpi.cc/2yboyPp

CABINET MATERIALS

Plywood (recommended) for the exterior, MDF for inside

- 48" (122 cm) piano hinge
- 24" (61 cm) soft-close drawer slides
- 2 × ½" (12.7 mm) overlay face frame concealed hinge (optional)
- Magnetic catch (optional)
- ¾" (19 mm) T-Molding (optional) – magpi.cc/2ybmvus

ELECTRICAL COMPONENTS

What you need to make – and power – your retro cabinet

27" LCD MONITOR

Old-school arcade machines had a CRT monitor, but they're heavy and prone to failure. LCDs just work better.

RASPBERRY PI

The brains of your entire project. We recommend a Raspberry Pi 3.

COMPUTER SPEAKERS

Want to hear your games? You'll need speakers.

SPEAKER GRILLES

magpi.cc/2ybuZ58

These allow you to hear what's playing through the speakers.

LED ARCADE BUTTONS

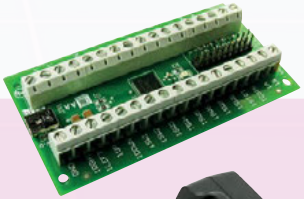
shop.pimoroni.com

Bash these buttons. You can get them from Pimoroni.

ARCADE JOYSTICK

magpi.cc/2za1AWI

Joysticks is the name of a bad Eighties comedy. These are better.



I-PAC

magpi.cc/2yDyLFi

This makes connecting your controls to the Pi as easy as… you get the idea.

12V POWER SUPPLY

Want to light up your cool LED arcade buttons? They need power.

SWITCHES & ASSORTED WIRES

Want to copy Bob's build exactly? Find his parts list on his blog: magpi.cc/2yU6whx

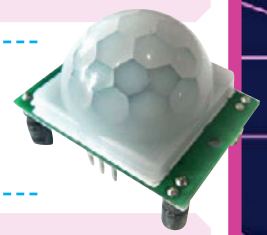
OPTIONAL

ARDUINO UNO

A microcontroller to control some of the electronics.

LED STRIPS

Cool lights for your new retro cabinet.



PIR SENSOR

A motion sensor unique to this specific build.

RELAY SHIELD

Building power control into the project? You'll need this.

LET'S GET BUILDING

Mario was a carpenter before he was a plumber. Time to borrow his old skills

01

MEASURE TWICE

If you've bought Bob's design, you can start measuring out the side panels on the plywood. If you want to go with your own design, make sure to do some research on the shape of the style of arcade cabinets you want to go with, and plan it out on paper or with CAD software first.

02

CUT ONCE

Begin cutting your panels out with your circular saw. Cut as close to the corners as you can and use a jigsaw or handsaw to finish them off. You can use this first side panel to trace an outline for the second side panel if you wish.

03

STRUCTURAL INTEGRITY

Now it's time to measure and cut out the main structure of the cabinet between the side panels using MDF sheets; this includes two MDF panels to hold the side panels together – albeit with a twist.

04

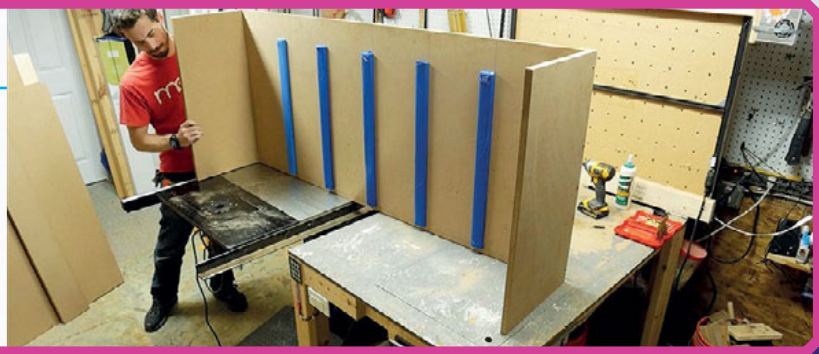
HIDDEN DRAWERS

In this build, one of the sides can open to reveal six hidden drawers. This is great for easily accessing the electronics inside and also using the cabinet for storage. Draw reference lines for six of the drawer sliders on each side and then attach them.

05

TOP TO BOTTOM

Make the top and bottom panels out of MDF and attach them using screws. Bob also added a bit of glue but reckons it's not entirely necessary. Add a bit of scrap wood in the open side just to help keep the shape for now.



06

FRONT BOOKSHELF

As well as drawers, there are hidden shelves inside the cabinet. These go at the front of the build and are short enough to be hidden by the front of the side panel. Create the basic rectangle/square shape of the shelves, and then add 1-inch (25.4 mm) spacers to the bottom of the frame before adding the bottom shelf on top for added strength and support.

07

SHELF FASCIA

Using the plywood, add a fascia to the front of the shelves to bring some consistency to the build. It will also look a bit nicer than the MDF on its own! These can be glued in place, but make sure they sit flush.

08

ADD SHELVES

Create two shelves out of plywood and screw them into place. Use your tools to make sure they're inserted straight and level.

You can also make doors for the shelves using extra plywood!

09

COMBINE THE STRUCTURE

Using clamps, make sure the rear cabinet section and front bookshelf section are properly lined up, and then drive screws through the back cabinet section to connect the two.

10

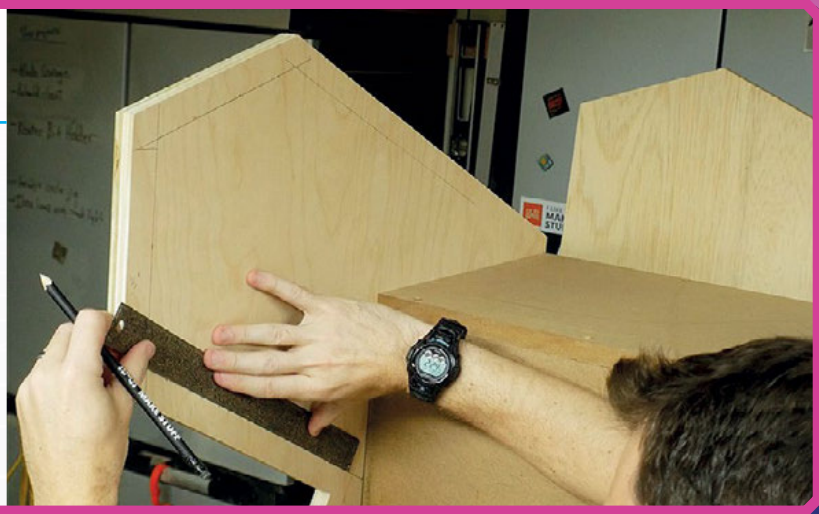
ADD A SIDE

Use clamps again to line the permanent cabinet side up with the side of the build. Make sure it's the opposite side to where you want the slide-out drawers to open. Screw it in on both the back cabinet and front shelf section to make sure it's secure.

11

TAKE SOME MEASUREMENTS

For the classic top of the arcade cabinet (where we'll house the speakers), you need to measure around the top of the side panel that's jutting out over and in front of the back pieces. Draw some guidelines starting from 1 inch (25.4 mm) away from the edge, and take into account the width of the wood, so you can figure out the exact size of the top piece.



12

FAKE SIDE PIECE

One side of the cabinet is going to swing open, which won't be good for the structure of the top piece. Create an extra top corner piece to help support the top bit, and screw it into place..

13

ADD SOME SUPPORT

Use scrap pieces on the fixed side to add support to the top piece – make sure they're inside the lines you measured out in step 11.

14

CUT THE TOP PIECE

Using all your measurements, cut the very top piece for the top section. Use your protractor, digital or otherwise, to create the mitre on the piece so the parts will fit together smoothly. Attach it to the supports with screws.

15

TOP BACK COVER

Bob cut a panel for the back cover and laid it over the top – it's not nailed down, so you can quickly access the inside of the top sections.

16

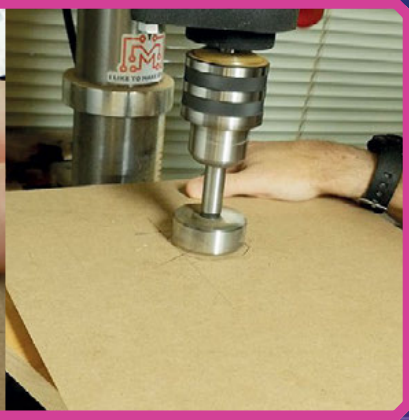
SPEAKER PANEL

The bottom panel of the top section is where the speakers will be attached. Again, using the guides you've made, cut out the piece and check to see if it fits.

17

SPEAKER HOLES

Disassemble your speakers and draw the outline of where you want to place them on the panel. Bob used a pencil to draw a couple of lines across the outline to find their centre, and then cut a big hole into it with a drill. Once you've cut the hole, double-check that the speakers line up with it.



18

ADD THE SPEAKER PANEL

Screw in the speaker panel to the top sections.

19

MARQUEE PREP

The front of the top section is used for the marquee, the front art, or lights in this case. To make the front look a little smarter, Bob added another bit of scrap wood just inside the hole to create a flush surface to add a better fascia onto the top section.

20

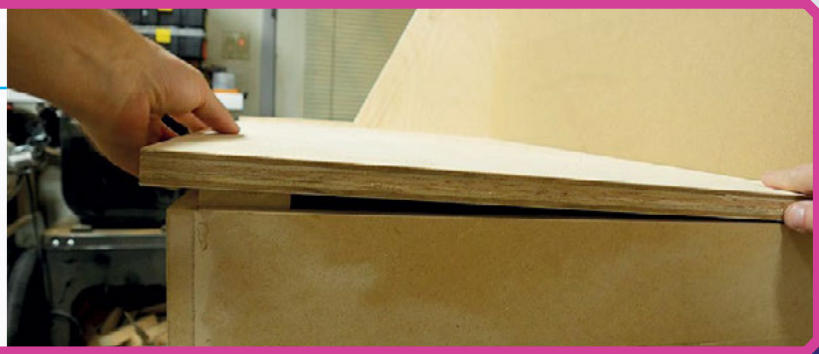
CONTROL BOX

Bob made a simple tray-like piece that will house the controls. It sits on top of the shelves at the front and does not extend beyond the dimensions of the side panels.

21

CONTROL BOARD

The board where the buttons and joystick will live merely covers this box. Bob added some blocks to the underneath of this board so that it can just easily and snugly rest on top of the control box for easy access.



22

MONITOR PANEL

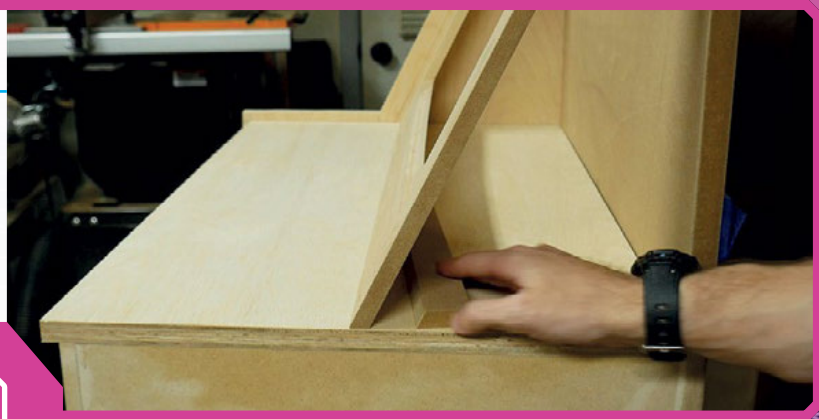
The monitor panel needs to be angled so you can look down and see the screen. Cut and mitre a piece of plywood so that it fits in the confines of side panel, top unit, and control board. Cut a hole in the centre to the size of the monitor you plan to use.

! Bob went one step further and used a CNC machine to cut holes that gave the illusion of a curved CRT TV, like in classic machines!

23

MONITOR SUPPORTS

Add a little strip of wood, mitred to the angle of the monitor panel, onto the control board to help support the panel. This way you don't have to permanently attach the monitor panel to the cabinet.



! Bob cut the strip into several small pieces that interlocked, with one piece on the control board and one on the monitor panel for extra stability.

24

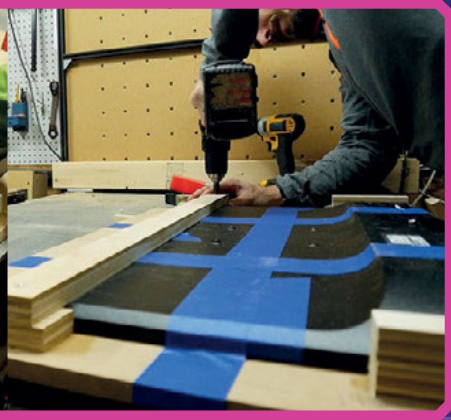
CUT THE BUTTON HOLES

Mark the holes for the buttons and joystick on the control board and cut them out.

25

BRACE THE MONITOR

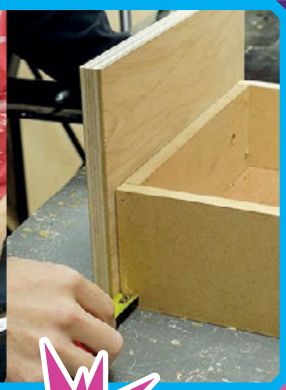
Tape down the monitor and measure to make sure it's correctly centred. Add two blocks to either side and then attach a piece over them to snugly clamp the monitor in place over the hole you created for it.



26

MAKE THE DRAWERS

Remember the drawer runners we added to the rear section of the cabinet? It's time to make the drawers for them. You can make them simply with a bottom and four sides if you wish, as long as it will fit. Don't add the runners yet, though.



27

AINT EVERYTHING!

It's time to paint the cabinet! Use some masking tape to cover up anything you'd rather not paint (like the runners) and get to it. You can use varnish or spray paint – Bob used a spray gun and did a light bit of sanding between coats. You'll need plenty of room for this!

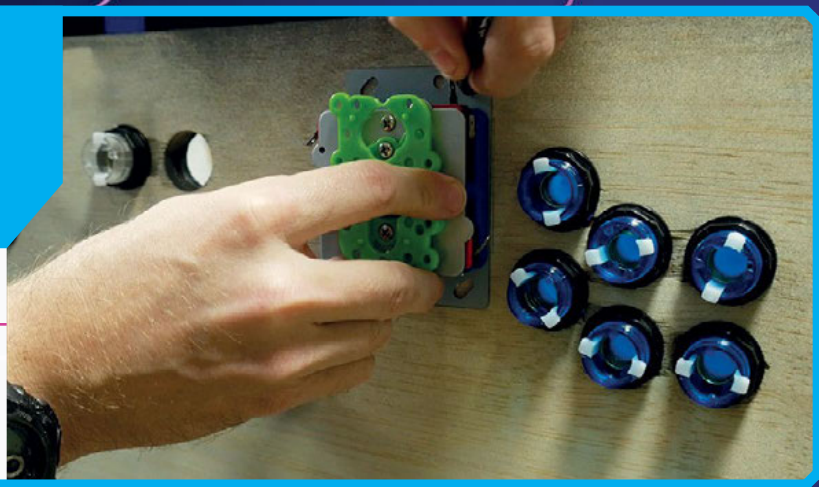
! If you want to add vinyls, add them when the paint is dry!

28

! If you want to add the T-Molding, you can do that now! Cut a small indent into the edge of the side panels and then use a rubber mallet to gently knock it into place.

ADD THE BUTTONS

Once the paint is dry, you can add the buttons and joystick to the control board. Affix them in place with screws.



29

ADD THE MARQUEE

In this build, the marquee is a print on something like clear acrylic so it can be lit up from inside. If you are doing something like this, merely glue it into the little hole of the top unit. Otherwise, attach a final piece of plywood to fill the hole. Paint a cool little graphic on there, though: it will look good.

30

ADD THE SPEAKERS

Add the speaker grilles to the outside of the top unit with screws, and then screw in the speakers on the inside.

31

FINISH THE DRAWERS

Remove one part of the runners for the drawers and carefully attach them to the side of the painted drawers before slotting them in.

32

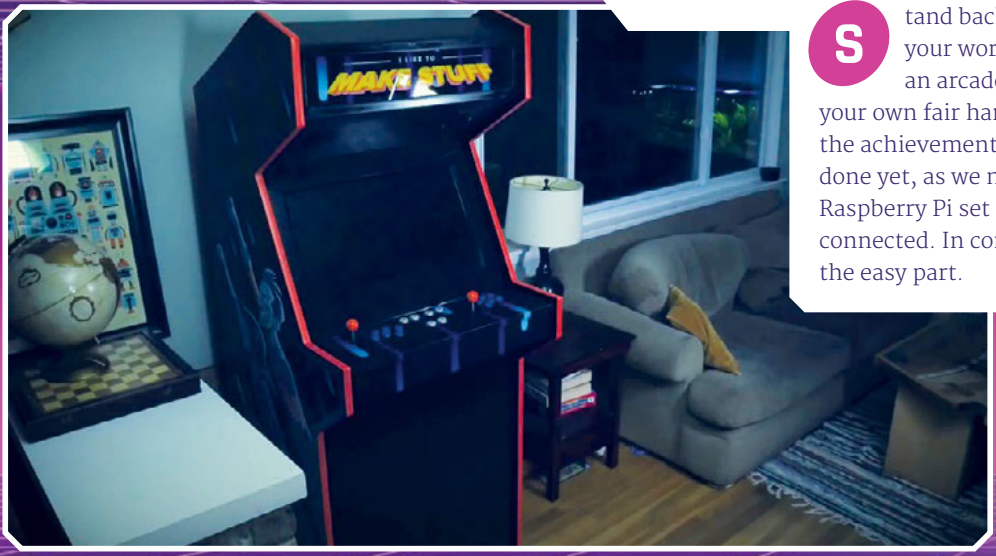
CABINET DOOR

Cut the piano hinge in half with a rotary tool, before attaching the halves to the back board on the open side of the cabinet. Attach the other side to the back edge of the side panel so that it can open and close. The standard build is now complete!

Want to do more? The original tutorial on Bob's website shows you how to add motion-activated LEDs to the build – great for a party piece: magpi.cc/2hBcDQK

SET UP YOUR RASPBERRY PI

Here's how to get your beautiful new cabinet to play some games

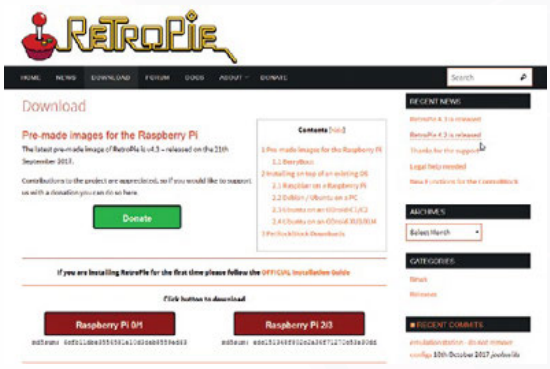


Stand back and admire your work. You've built an arcade machine with your own fair hands! It's quite the achievement. We're not quite done yet, as we need to get the Raspberry Pi set up and everything connected. In comparison, this is the easy part.

CONFIGURE RETROPIE

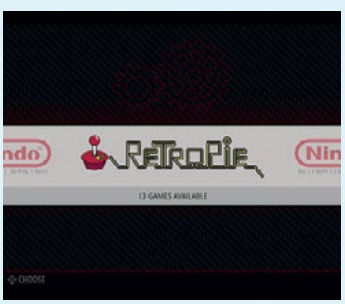
GET RETROPIE

Head to the RetroPie website and grab the latest image of RetroPie (**magpi.cc/25UDXzh**). You'll then need to install it to an SD card using Etcher – you can follow along to our tutorial video to do this if it's your first time: **magpi.cc/etchervid**.



INITIAL SETUP

Put the SD card in and boot up your Raspberry Pi. Go through the initial setup just to get it going – you'll have to do the controller configuration again once you install it into the cabinet, though.



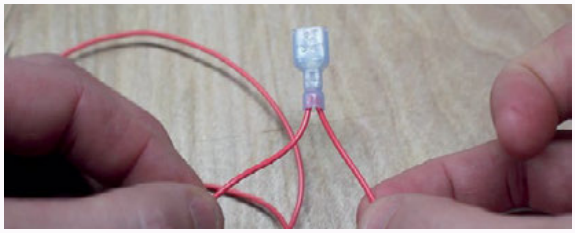
LOAD YOUR ROMS

It's easier to get any of your ROMs loaded onto the SD card now, before you put the Pi into your arcade cabinet. You can always take it out later as we built it to be accessible if you want to add or remove ROMs, though. You can find the info on how to do this here: **magpi.cc/2hBznjB**.

WIRE UP THE CONTROLS

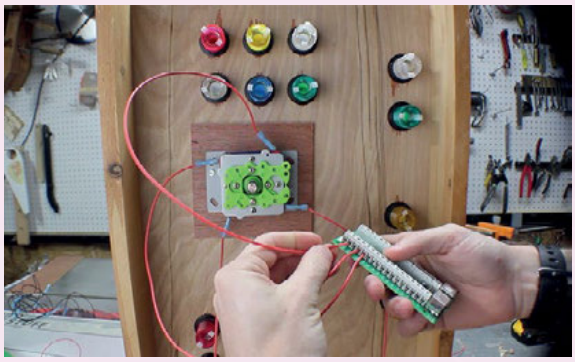
PREPARE THE WIRES

As we're using light-up buttons, we need to provide power for the LEDs in them. You can do this by creating a daisy chain of power and ground wires that will connect all the lights. This is most neatly done by adding them to female plugs that slot onto each button's connectors. You'll also need individual wires for each button and joystick output, and a daisy chain of connectors like the power and ground ones for the ground connections of the inputs.



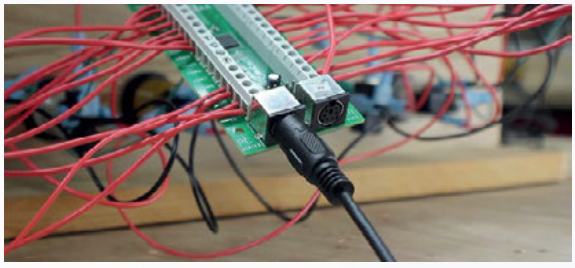
WIRE IT UP

Connect the individual control wires and input ground to the corresponding ports on the I-PAC board, and also connect your daisy-chained power and ground wires to the buttons/joysticks on one end and the screw terminal at the other.



CONNECT TO PI

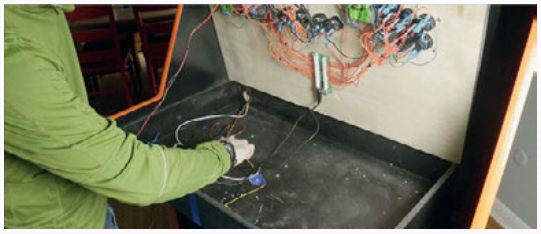
The I-PAC can now be connected to the Raspberry Pi using the USB cable. Load up control configurations to set the correct inputs for players one and two.



CONNECT IT ALL UP

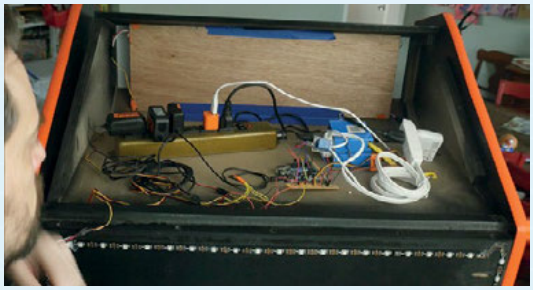
THE CONTROL BOX

Your Pi can now live in the control box under the buttons. All you need to do is run power for the Pi and the HDMI cable for the monitor through the box – you can do this with some well-placed holes behind the monitor or through the back of the cabinet.



POWERING IT ALL

You'll need several plugs to power all of this, even in its most basic configuration. The Pi, LEDs in the buttons, and monitor will all need power. You can just plug them all into the wall, but we suggest getting a (surge-protected) power strip and plugging all the parts into that. Have a lead run out of the back to plug it in and turn the whole system on. If you're doing Bob's full build, you can go a bit further and add a relay switch and more.



TURN IT ON!

You're ready to game. Get a soda and some Doritos to complete the experience and enjoy your own personal arcade cabinet. Happy gaming!

OTHER ARCADES

Want an arcade machine, but would like to try something a little different than our build? Here are some alternatives...

SUPER PIE

magpi.cc/2yFTPes

Still want a classic arcade cabinet you can stand up, but don't want to bother with the extra storage? Pierre Sobarzo's Super Pie is a simpler build, albeit with many of the same considerations for electronics. His also has coin slots for added authenticity.

The Imgur album doesn't quite have the same build instructions, but you can absolutely use it as a guide to simplify the build on the previous pages.

ARCADE PI

magpi.cc/1Q5gGw8

The simplest way to experience the arcade at home, and with comfort, is to just build an all-in-one arcade stick with a Pi – and therefore games – hidden inside. All you need is a long HDMI cable. You can buy ready-made kits that will let you build these, but this version has full instructions you can copy along to.

We like these style of plug-and-play controllers as they're quick to make, look great, and are extremely versatile.

BARTOP ARCADE MACHINE

magpi.cc/1q0xaVh

What makes up the arcade experience? Do you have to be in the corner of the room standing at a bulky device purely to play games? Bartop arcade machines like the Galactic Starcade take up less space, but still give the arcade experience of playing with a stick.

This build is also a lot easier to do as you don't have to paint and move a massive wooden structure around. You can also just plonk it on a table when you want to get it out and play some Elevator Action.

PIK3A

magpi.cc/1q0xwLG

The cocktail arcade machine is a popular old-school variant of the traditional arcade cabinet, especially for custom builds. It allows you to use the space as a table as well, and two players don't have to crowd around one side of the machine to play multiplayer.

This Pik3a uses the LACK side table from IKEA in its construction, giving it a very unique look, but there are plenty of other cocktail arcade machines you could take inspiration from.

MINI ARCADE

magpi.cc/1V8XEvY

Want a full arcade cabinet but also the space and portability of the bartop arcade? How about a mini replica of your favourite arcade machine? Tiburico de la Carcova has a selection of mini arcade machine replicas, but the most popular one is his Galaga setup.

It includes accurate art stuck to the panels and, more importantly, it's only a couple of feet high. He keeps his on display and only playing a single game, but there's no reason not to make yours multipurpose.

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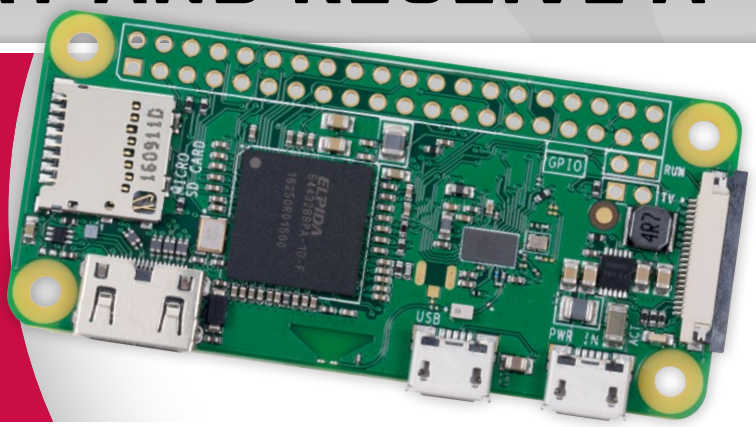

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POPPY MOSBACHER

A Sustainable Design student at the University of Brighton who won a Blue Peter robot design competition, aged eight.

magpi.cc/2xRmUjR

When someone stands inside the frame, Take Photo is pressed on the laptop software, and the images are taken and saved
Pi Zero Ws and cameras are housed in laser-cut 5 mm single-walled corrugated cardboard
Tubes, of varying lengths, are attached to each other using connectors and self-adhesive touch fasteners

3D BODY SCANNER

Poppy Mosbacher has created a relatively inexpensive full-body 3D scanner, and she hopes maker groups will enjoy replicating her project!

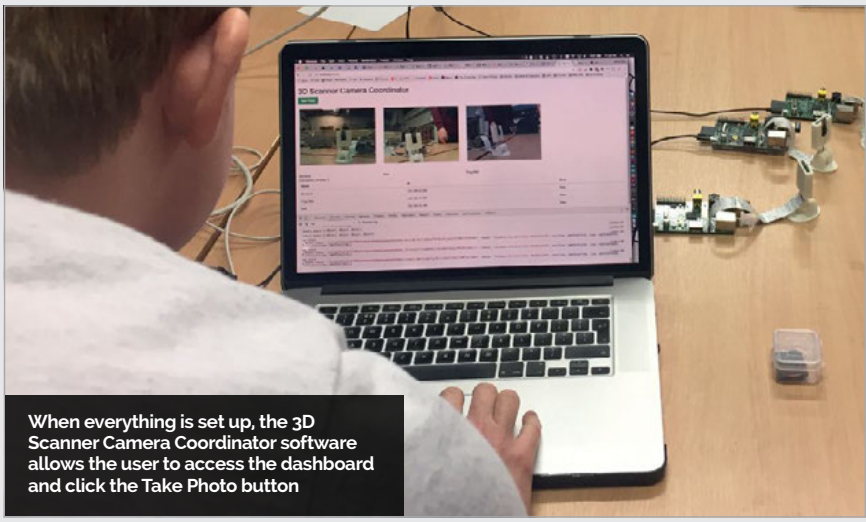
Quick Facts

- The project's Pis are named after Marvel characters
- Poppy wanted the build to cost less than £1,000
- The images are processed using Autodesk ReMake
- Build Brighton members got fully involved in the project
- It uses mains electricity, so be careful!

While learning to make her own clothes, Poppy Mosbacher wanted to visualise how they would look before she made them, and she began to think about how digital technology tools could help.

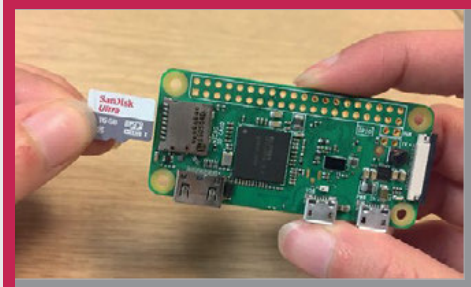
At first, she considered using a body scanner, but after talking to a friend, she learned that high-end 3D scanners using DSLR cameras can cost as much as £40,000. Just as bad, the cheapest alternative – of simply walking around an object or person and taking lots of photos with a single camera – proved slow and frustrating.

It was then that her friend and member of the not-for-profit makerspace Build Brighton, Paul Hayes, suggested that it might be easier to make a DIY version of a 3D scanner using Raspberry Pis. Before long, Poppy had secured a £1,000 grant from Santander, which she used to buy 27 Pi Zero Ws (each snapped up by a different Build Brighton member to get around the one-per-customer rule). She also bought 27 Camera Modules, 27 Pi Zero camera cables, and 27 USB to micro USB cables, as well as an assortment of battery packs, power regulators, wire connectors and other electrical items.

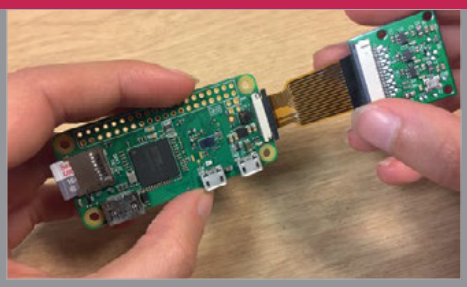


When everything is set up, the 3D Scanner Camera Coordinator software allows the user to access the dashboard and click the Take Photo button

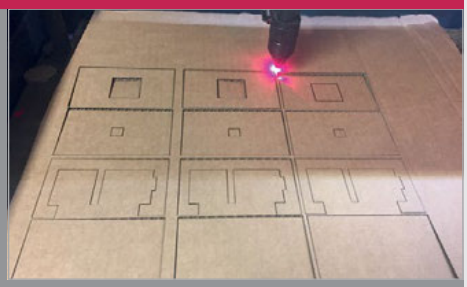
PREPARING THE PIS



>STEP-01
Code the Pi
Prior to her project, Poppy had only used the Raspberry Pi once, at a workshop at the Mozilla Festival in 2015. Arthur Guy wrote the actual code, which needs to run constantly.



>STEP-02
Connect the camera
After setting up the server so that the cameras know which fixed IP address to send the photos to, a computer is connected. The cameras are then hooked up to the Pi Zero Ws.



>STEP-03
House the Pis
The Pi Zero Ws and the cameras are housed in these cardboard cases, which are then placed around the structure. A 5V power regulator can be connected to up to three Pis.

Cardboard engineering
Inspired by Richard Garsthagen (**magpi.cc/2xVr3Vr**), Poppy then looked at making the scanner affordable and portable. "The idea of having a portable rig that people could step into and take a picture in a few seconds was appealing," she says. By using Zero Ws, she hoped the scanner could be replicated in the future for less than £1,000. To keep costs low, and to make the build easier for Poppy and the Build Brighton team, twelve 3mm-thick cardboard tubes were used, on which the Pis and their cameras were mounted.

> "Twelve 3 mm thick cardboard tubes were used, on which the Pis and their cameras were mounted"

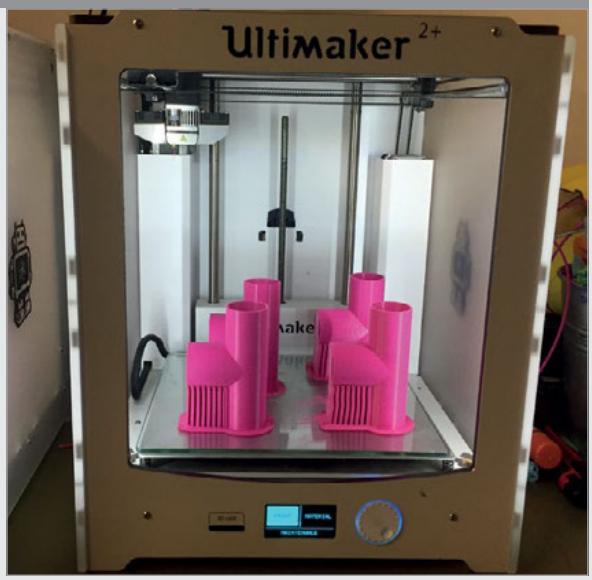
Poppy says the cardboard proved to be "a great material to cut and make holes in." As well as the cardboard frame, a cardboard case was designed for the Pi Zero Ws. "It also helps hide the wires," she adds. Created to work within the smallest possible diameter so that it can remain portable, the idea was to connect the Pis to a laptop to trigger the photos, so that all the cameras would take a snap simultaneously.

Coding challenges
"The photos are sent wirelessly to the laptop and they are automatically saved in a new folder," Poppy explains. Raspbian Jessie Lite is installed on the Pis, and the main server runs a node application. Another friend, Arthur Guy, wrote the code for the scanner in JavaScript, building it up week by week, and adding features such as getting the Pis to look for updates on startup so that they all use the latest version of the software.

There were still some issues along the way, and a fair bit of trial and error, especially in positioning the cameras so that the photogrammetry software could digitally stitch the images together. There was also a problem with Poppy's shiny long hair, which became apparent when she stood inside the structure. "I looked online, and it suggests putting powder on anything shiny, but I haven't tried it yet."

Some problems proved easy to overcome. Figuring out which cameras weren't working was solved by assigning them names, and Arthur also learned to change the white balance on the cameras to improve the image quality. Yet there are problems with time lag. "Some Pis take a photo instantly, and others take a few seconds, so we have to stay still until all the photos have been taken," Poppy says.

Nevertheless, she is excited about future applications for the project. "It opens up new possibilities, such as of scans of children who won't stay still long enough for the single camera method; building a personal database of scans taken at regular intervals to see the effects of aging; and making avatars for VR environments."



Above Eight cross joints and four T-junctions were 3D printed using an Ultimaker 2+

KEVIN S LUCK

Kevin S Luck is a PhD student at Arizona State University working on robots and new machine learning methods with Joseph Campbell and Michael A Jansen.
magpi.cc/2yzh4pu

C-TURTLE

Building a Pi-based robot only to blow it up may sound like a waste, but this mine detector could save lives

Quick Facts

- The total cost of a C-Turtle is about £50
- The goal is to create an autonomous fleet
- The experimental learning algorithm was written in MATLAB
- C-Turtle learned to move optimally in an hour
- It will blow up discovered land-mines – and itself

It's a sad truth, but right now the world is littered with an estimated 110 million land-mines. Clearing them all could take as long as 1000 years and cost $30 billion, but leaving them in situ is not an option. The number of people killed or injured by these hidden weapons recently reached a ten-year high – so how amazing would it be if the Raspberry Pi could help tackle this ever-present problem?

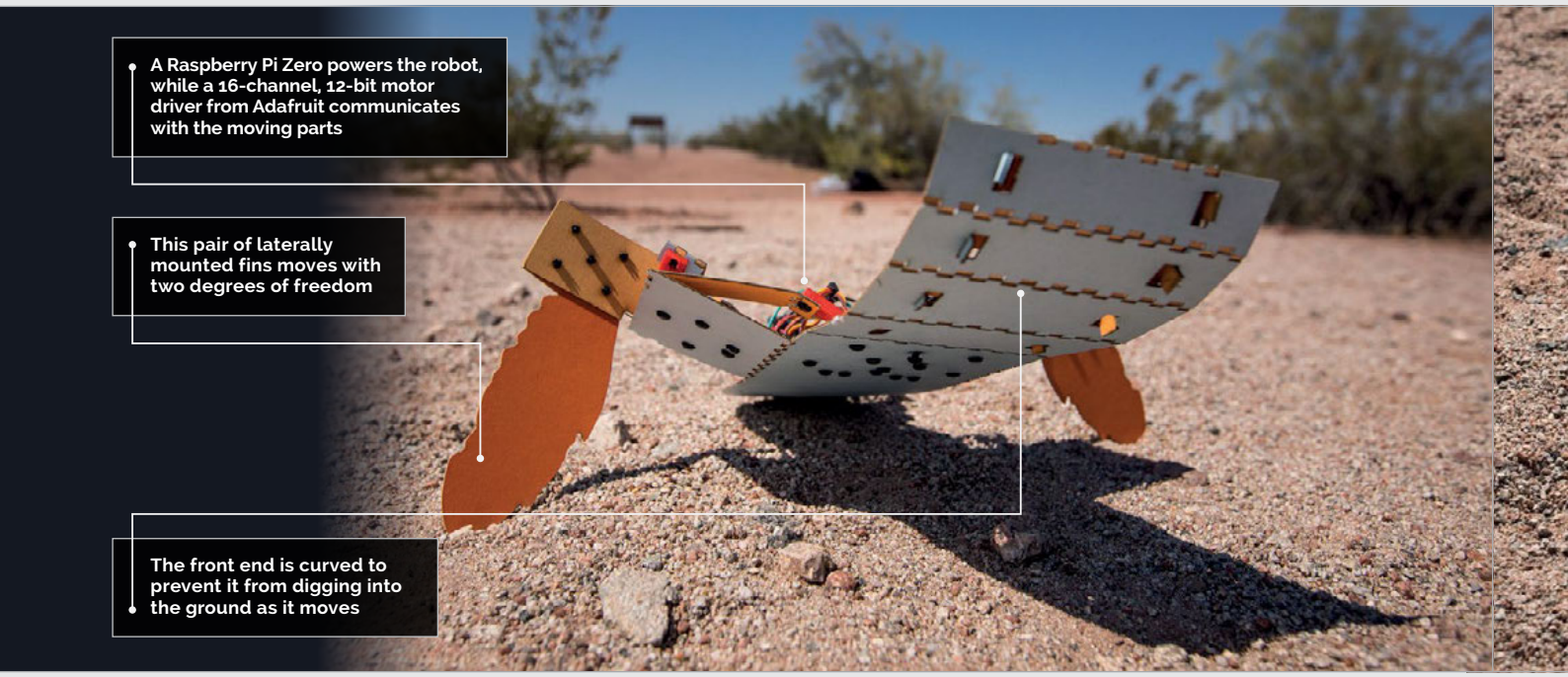
Cardboard demining

Scientists at Arizona State University have been putting their heads together to do just that. They have devised the C-Turtle, a cardboard robot with turtle flippers which has a Raspberry Pi at its heart. It uses machine learning to figure out how to walk across the most unusual and hazardous of terrain, constantly adapting to its surroundings. Modelled on a sea turtle (hence the name), it is not only inexpensive, but easy to transport.

"We were looking to develop a cheap and simple robot for the detection of land-mines," says PhD student Kevin S Luck, who has worked on the project with Joseph Campbell and Michael A Jansen. "Undetected land-mines are a problem in many countries, and often these mines are particularly difficult to detect in sandy environments. The problem is that sand in a desert moves over time and so the location and depth of the land-mines is constantly shifting."

Inspired by nature

The C-Turtle is well equipped to cope with this issue. Housed within a single-sheet laminate comprised of layers of paper, foil and adhesive, it mimics the movement of a sea turtle. The scientific trio had noted how quickly sea turtle hatchlings can move over sand and how adults crawl while lifting their immense weight. This led to Michael developing a workable fin shape, and Kevin and Joseph figuring out how the Pi could best power the robot.


A Raspberry Pi Zero powers the robot, while a 16-channel, 12-bit motor driver from Adafruit communicates with the moving parts
This pair of laterally mounted fins moves with two degrees of freedom
The front end is curved to prevent it from digging into the ground as it moves

"We envisioned a system where each robot can carry sensors to detect and mark land-mines, but also where the loss of a single robot is relatively inconsequential for demining operations, thus reducing the risk for humans or bigger demining robots," explains Kevin. During the design process, some key decisions were made. They ruled out using wheels – "they usually have issues with slippage on sand, and they would create a more complex manufacturing process," says Kevin – and were unanimous in wanting to use a Raspberry Pi Zero.

Lightweight connectivity

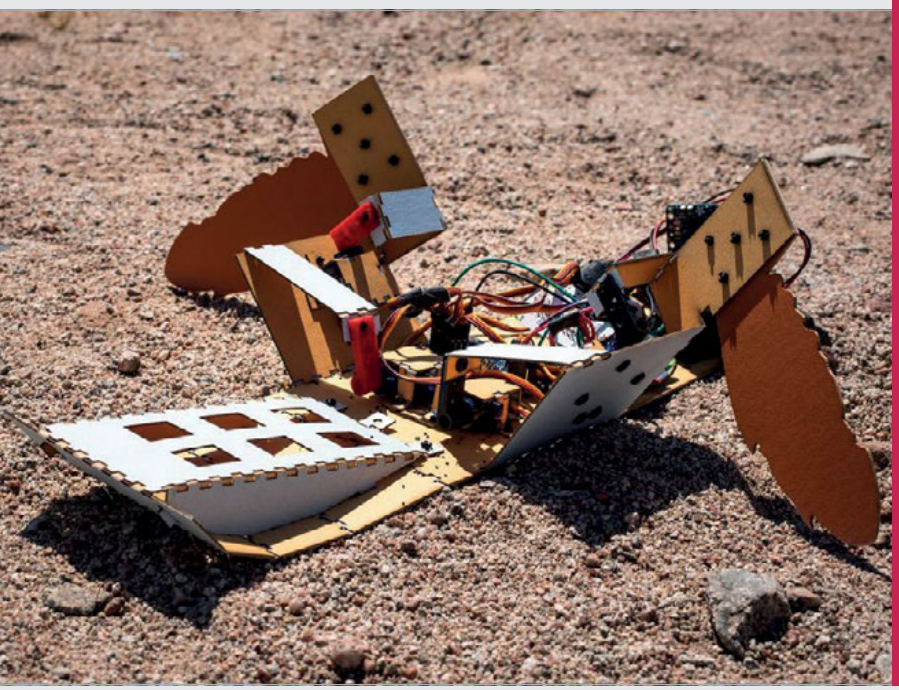
"The Pi felt perfect," Kevin continues. "We not only wanted the ability to send commands to the robot via WLAN, but also to perform simple data processing and machine learning directly on the robot – a requirement for using multiple robots in a fully autonomous fleet. The Zero also requires relatively little power. Because of that, we're exploring the possibility of using solar panels for recharging batteries during the daytime."

Kevin and Joseph have worked on an algorithm which allows the turtle bot to adapt its crawling technique. "The whole code infrastructure on the turtle robot, from motor control to the joint server and sensor collections, was written in Python," Kevin reveals. "We used TCP/IP connections to send joint commands to the robot and also to collect data for evaluation."

Real-world learning

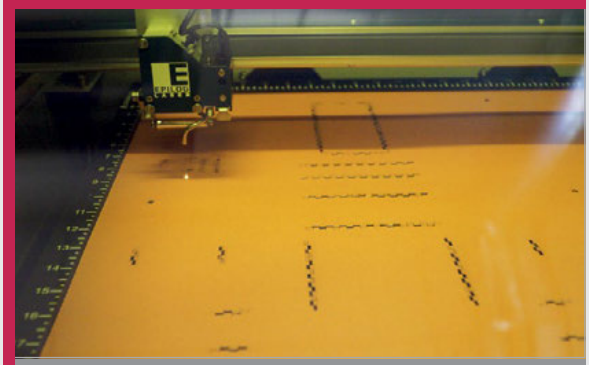
This was put to the test when they drove out into the desert with their first prototypes. "We got a real-time feed of what was happening with our robot, and were able to test and debug different variations of the learning scenarios," Kevin tells us. By using trial-and-error learning, the robot gets good and bad feedback which enables it to develop.

Through this process, the robot has managed to work out effective trajectories over poppy seeds as well as sand, but the scientists are continuing to refine the technology and their ambitions remain high. "We'd like to take the robots into space, too," says Kevin. "It would be fantastic to use them to explore Mars."



Below Tests are ongoing to find out how well the robot, and the Pi, cope in extreme temperatures

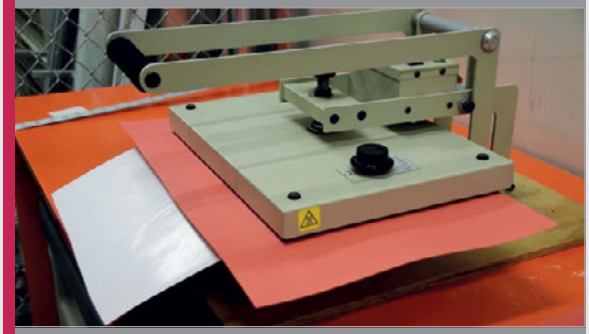
CREATE THE C-TURTLE'S BODY



>STEP-01

Laser-cut the layers

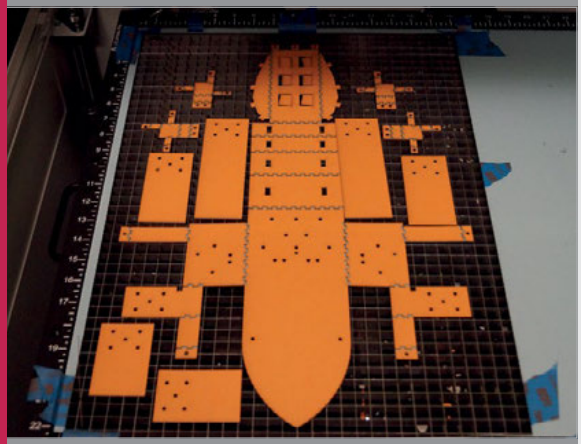
The cardboard layers are laser cut. For each of the five layers (two cardboard, two adhesive, and one foil), holes are cut in specific locations to allow hinges to be fitted later.



>STEP-02

Begin the lamination

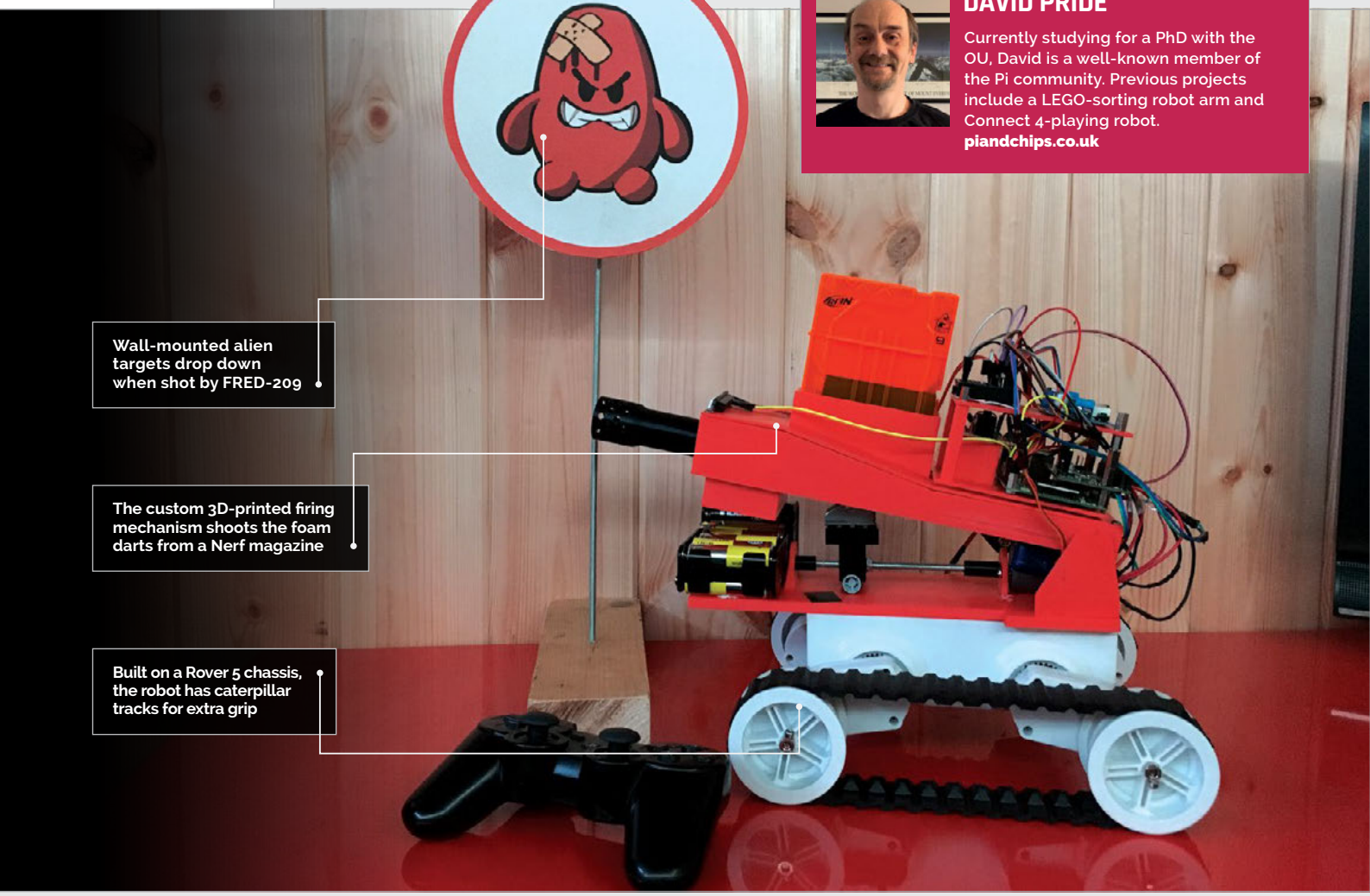
Once the layers are cut, they are laminated together to form a single layered sheet using a heating press.



>STEP-03

Ready for assembly

The shapes of the individual parts are cut from the laminated sheet. The holes are mounting holes, designed to be used with rivets.


Wall-mounted alien targets drop down when shot by FRED-209
The custom 3D-printed firing mechanism shoots the foam darts from a Nerf magazine
Built on a Rover 5 chassis, the robot has caterpillar tracks for extra grip

DAVID PRIDE

Currently studying for a PhD with the OU, David is a well-known member of the Pi community. Previous projects include a LEGO-sorting robot arm and Connect 4-playing robot.
piandchips.co.uk

Quick Facts

- It currently runs on 14 AA batteries
- The firing mechanism is mainly 3D-printed
- David plans to add a camera
- He'll upload the STL files for 3D printing
- FRED-209 is sadly too big for Pi Wars

FRED-209

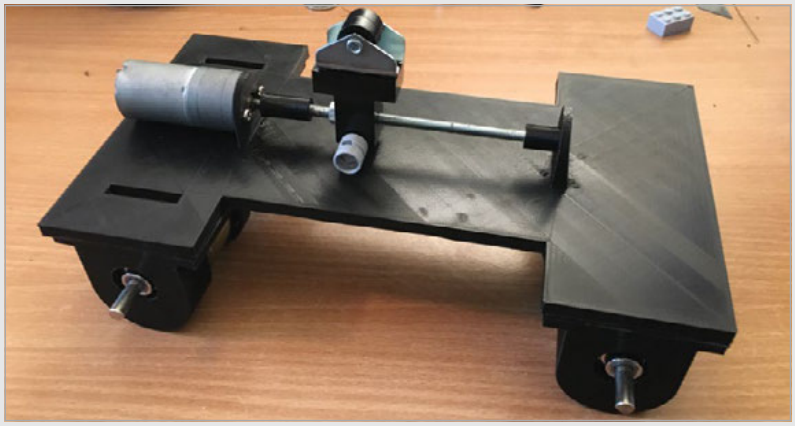
Say hello to **David Pride**'s Nerf-toting robot! You have 20 seconds to comply...

While well-known Pi community member David Pride admits that Nerf guns hadn't been invented when he was a youngster, his interest was sparked when he saw two tables full of Nerf gear at a car boot sale. "I started wondering whether you could operate the trigger mechanism with a servo – turns out you can!"

Following some successful experiments firing smaller, single-shot Nerf guns using a servo, David turned his attention to larger Nerf models. "[I] realised that there are essentially two types: the pump action ones and those which use two flywheels to propel the dart. I didn't know exactly how the mechanism worked until I actually took one to bits!"

Initially, David simply strapped an upside-down Nerf gun to the top of his 2017 Pi Wars robot, X-Bot. "I realised that this wasn't really going to cut it, so set about designing and 3D-printing a complete setup that I could mount on top of a bot. It uses the original Nerf flywheels, and the original Nerf magazine which can hold six darts. The rest is all 3D-printed. I also designed a simple mechanism to translate servo movement into lateral movement to push the dart into the launcher."

During the two months of evenings and weekends he spent working on the project over the summer, several design changes were made. "The biggest disappointment was that the huge chunky motors I had didn't have enough torque to turn the



Above A long threaded bar converts motor rotation into lateral movement to tilt the whole firing mechanism (not shown) up or down for aiming purposes

bot successfully. Getting the right motors is an area where I am definitely still learning and it's a critical factor to get right in building a successful bot."

Since he'd already bought a Dagu Rover 5 chassis, David opted to mount his Nerf mechanism on that until he obtained some stronger motors. He also dropped the original chunky wheels in favour of smaller ones with caterpillar tracks.

> "It uses the original Nerf flywheels, and the original Nerf magazine which can hold six darts"

Controlled manually using a wireless PS3 joypad, FRED-209 can fire multiple foam darts at the chosen target(s). Its twin motors are driven using a ZeroBorg board, while the firing servo is connected directly to the GPIO 18 PWM pin on the Raspberry Pi. A tilt mechanism for aiming is controlled by the joypad's shoulder buttons.

David describes the robot's public debut at the Cotswold Jam as 'controlled chaos'. "It went down extremely well. I built some 'evil alien' targets to give the participants something to aim at – apart from each other!"

Continuing work on the project, David plans to power it with LiPo batteries – "It currently runs on 14 (!) AA batteries which really don't last very long as the drive motors and flywheel motors are pretty greedy."

He also plans to add a camera to enable FRED-209 to find and fire at targets automatically. "I did some very simple vision processing for 4-Bot, my Raspberry Pi Connect 4 robot, but this takes it up several levels. I am currently learning OpenCV and SimpleCV for vision processing... The plan is the bot will recognise colour/shape to locate target. I can see it working well as a burglar detector... providing the burglar is wearing a black and white stripy shirt and carrying a bag marked 'swag'!"

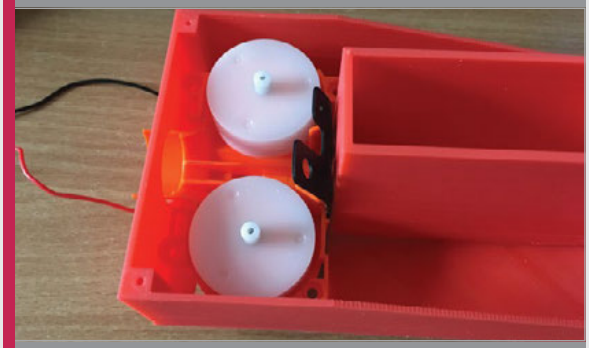
Left David originally tried mounting a standard Nerf gun on the top of a robot, but soon realised that it wasn't really going to work that well

BUILD A NERF DART-FIRING ROBOT

>STEP-01

Servo pusher

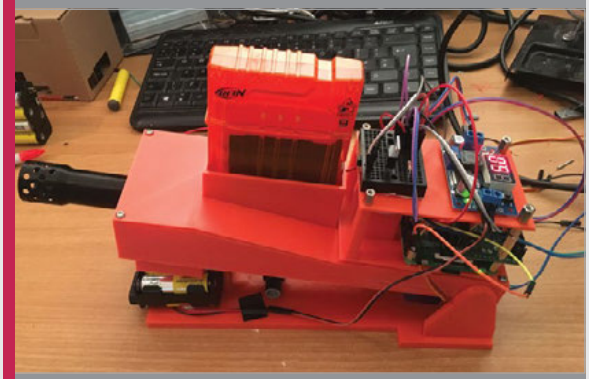
David 3D-printed most of the parts for his Nerf firing mechanism, including the servo pusher. An arm connected to the servo moves a rod forward to push the dart from the magazine.



>STEP-02

Flywheel flinger

The dart is pushed into twin rotating flywheels which propel it rapidly down the barrel. These, along with the robot's drive motors, require a lot of battery power.



>STEP-03

Completed mechanism

The 3D-printed lid has a slot to load the upside-down Nerf gun magazine. A roller underneath moves along to tilt the whole mechanism up and down to aim.

JEREMIAH MATTISON

Jeremiah is a Software Engineer for the PNI Sensor Corporation in Santa Rosa, California. He spends his free time tinkering with sensors and writing software for them.

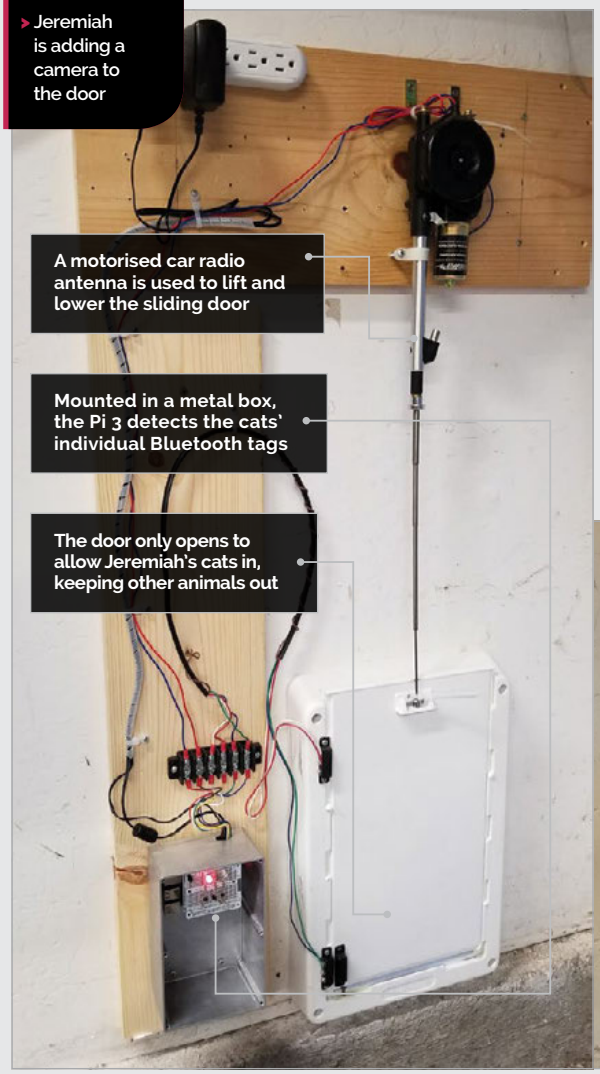
magpi.cc/2ko6qMG

RPI 3 BLE CAT DOOR

To limit access to his home to just his own four cats, **Jeremiah Mattison** built a Bluetooth tag-sensing motorised pet door

Quick Facts

- Build details are on Hackster (**magpi.cc/2ko6qMG**)
- The cats wear Tile Bluetooth tracker tags
- Magnetic switches limit the door's movement
- The software is all in Node-RED
- Jeremiah is adding a camera to the door


A motorised car radio antenna is used to lift and lower the sliding door
Mounted in a metal box, the Pi 3 detects the cats' individual Bluetooth tags
The door only opens to allow Jeremiah's cats in, keeping other animals out

Living in Santa Rosa, California, Jeremiah Mattison had a major problem with critters getting into his house through his pet door. "There are many cats in the neighbourhood and I was getting woken up every night by them trying to get into the bulk food. Additionally during the fall, in what I have coined 'Racktober', we have a problem with raccoons as well."

The solution was to create a tag-sensing motorised pet door to enable his four cats to get in, but keep other animals out. After a failed attempt based on an Arduino and passive RFID tags, Jeremiah found the purr-fect solution using a Pi 3 and Bluetooth Low Energy (BLE) tracking tags. "The [RFID] tags had to be really close to the antenna," he recalls. "The BLE tags are battery powered, so they

Below The door will stay open so long as the Bluetooth tag is in range; when not, it closes after 15 seconds

have greater range and I can use the RSSI metric to control the distance at which they trigger the door."

To slide open the Ideal Ruff-Weather pet door, Jeremiah originally planned to use a stepper motor with a track or pulley system, but ended up using a motorised car antenna instead. "[I] somehow found myself on a forum thread with people talking about using automotive antennas for DIY automated chicken coop doors. They were just using a simple timer to open and close the door, which wouldn't work for my project, but the antenna part was perfect."

Controlling the door

Mounted in a metal box to one side of the pet door, the Pi 3 is stacked with two Adafruit Perma-Proto HATs wired up with the extra electronics required – including an H-bridge circuit to drive the motor, and three status LEDs. The blue LED flashes whenever the Pi – programmed using Node-RED – senses a permitted Bluetooth tag within range, currently set to around 2 metres. "This allows the door to open far enough in advance not to spook the cats, but still minimise the time open so other animals can't sneak in."

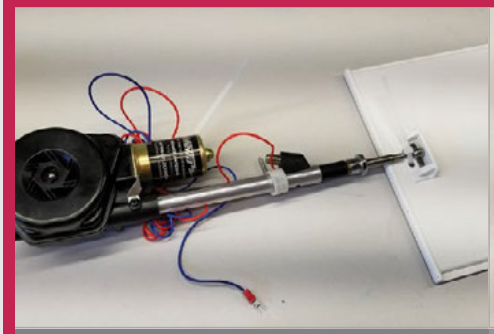
The door waits 15 seconds after the last BLE trigger before closing, which Jeremiah says should be more than enough time for the cats to make it through safely. "There was one time where one of the cats had come into the garage and I walked out and spooked him, sending him running out the cat door right as it was closing so it nicked him a bit; but there's not much resistance on the automotive antenna so it didn't really do anything."

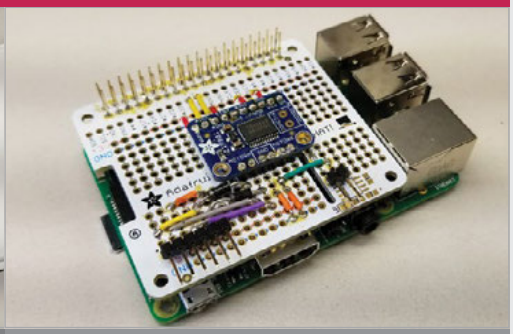
> "Jeremiah found the purr-fect solution using a Pi 3 and Bluetooth Low Energy (BLE) tracking tags"

The reaction of his cats to the new door has been mixed. "Two of them are mostly outdoor cats and they had no problem adjusting to the cat door, and even still use it when the garage door next to it is open. The other two are skittish, mostly indoor cats and are still getting used to it."

To enhance the project, Jeremiah has just mounted a security camera outside the cat door and – as well as snapping photos of critters to tweet via a Twitter bot – plans to use it for image recognition to enable tighter RSSI settings for more accurate door triggering.

CREATE A SMART PET DOOR





>STEP-01
Motorised door

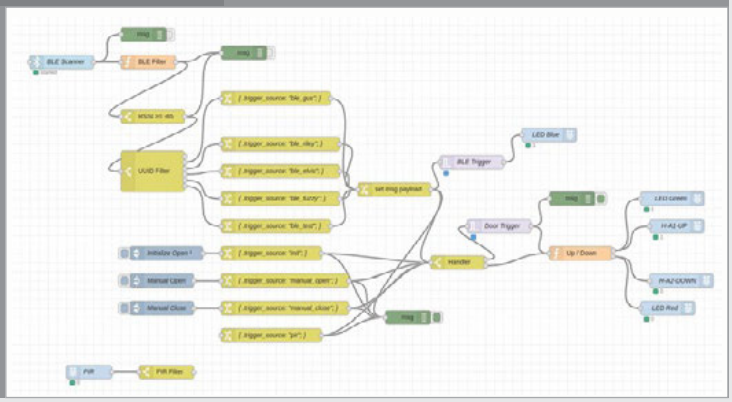
Jeremiah used a 12V motorised car antenna, mounted upside-down, to lift and lower the sliding pet door. He ripped out the control circuit and used the motor wires directly.

>STEP-02
H-bridge motor driver

Wired up on a Perma-Pro HAT, the H-bridge circuit that controls the antenna motor features an Adafruit TB6612 breakout board, plus 1N4001 diodes to protect from reverse voltage.

>STEP-03
Node-RED flow

After trying to use Python, Jeremiah opted to use Node-RED for the software, employing a BLE scanner node to detect the named Bluetooth tags worn by his four cats.



Above Each cat wears a Tile Bluetooth tag which is detected by the Pi when in range, to trigger the door

MIKE'S PI BAKERY

MIKE COOK

Veteran magazine author from the old days and writer of the Body Build series. Co-author of *Raspberry Pi for Dummies*, *Raspberry Pi Projects*, and *Raspberry Pi Projects for Dummies*.
magpi.cc/259aT3X

You'll Need

- Raspberry Pi 3
- Adafruit Music Maker FeatherWing board **magpi.cc/2yv8d57**
- 6N138 optical isolator
- 1N4001 diode
- 3V3 regulator and capacitors
- 5-pin DIN socket
- 2.1mm power jack
- Stripboard and resistors
- 16-way and 12-way female header sockets

MIDI SOUND BOX

Make a standalone MIDI sound generator

A couple of months back, in issue 61, we showed you how to make a Polyrhythmic Sequencer, which used a MIDI output. While it is possible to find second-hand MIDI sound generators, there are not many new ones available these days. For the computer hobbyist, hardware sound generators are great for use in experimental projects. There is a popular chip, the VS1053, which is used in a lot of MP3-playing modules. What is not well known is that this chip also has a direct MIDI input. In fact, many boards that use this chip do not even track out this pin, so it tends to be overlooked. This month, we have taken a board that features this chip, and used it to make a standalone MIDI sound generator.

The chip is used in several Adafruit Music Maker products. We have taken the cheapest of these boards, the Music Maker FeatherWing, and hacked it so it will work alone. The board is designed to be plugged into one of a series of small processor boards called Feathers, but for a straight MIDI interface this will not be needed. All we have to do is provide the Music Maker FeatherWing with a 3V3 voltage, and build a MIDI interface to feed the serial MIDI input.

The circuit

A MIDI input interface consists of an optically isolated input from a standard-size 5-pin DIN socket. There is a diode on the input to prevent any damage (for example if a cable has been wired the wrong way

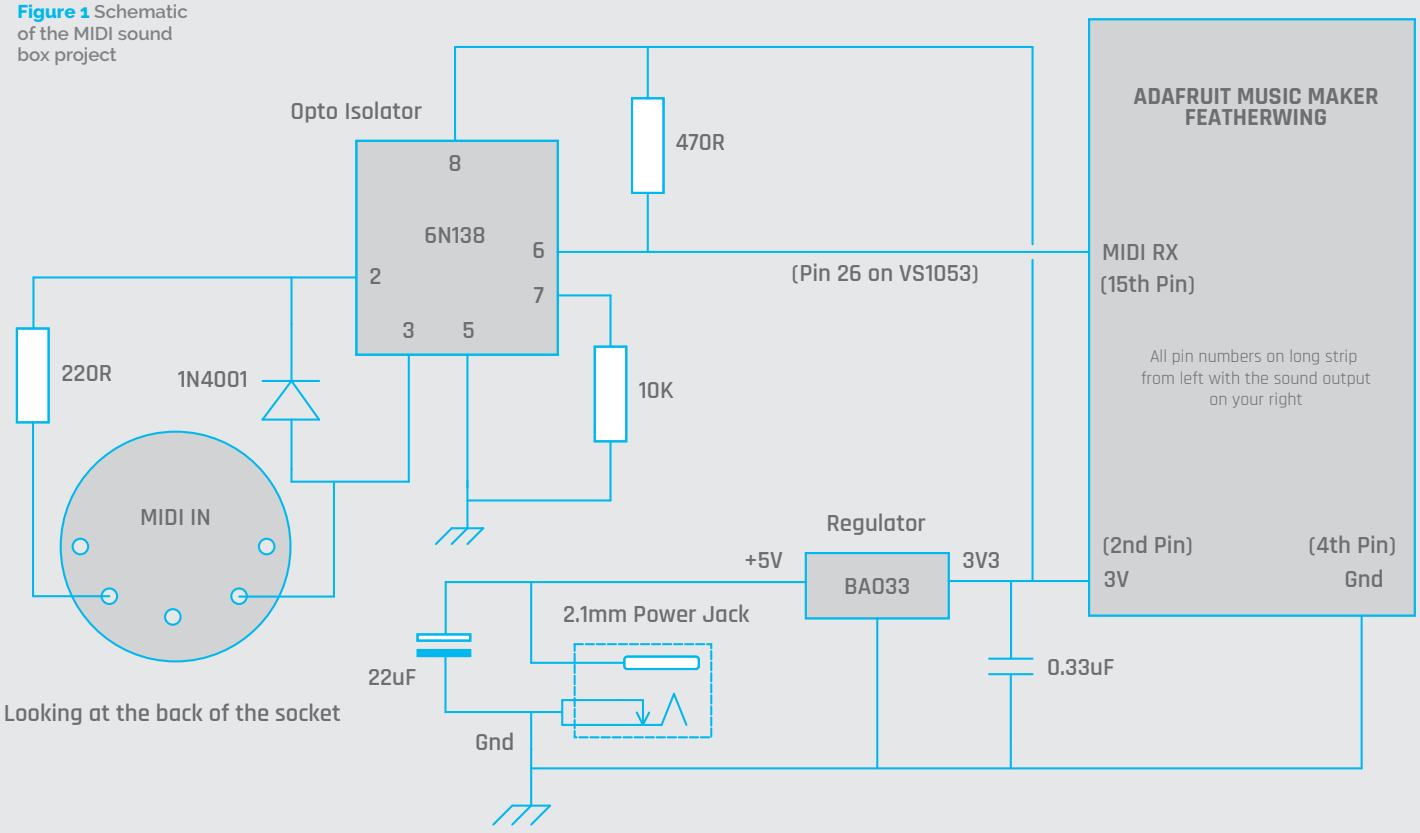


Figure 1 Schematic of the MIDI sound box project

round), and also a current-limiting resistor for the LED inside the optical isolator. On the output side, a Darlington transistor pair picks up the infrared light from the LED and amplifies it. This signal can then be sent to the MIDI input of the VS1053. We need to feed the board with 3V3, so we have included a voltage regulator to do this.

The whole circuit is rather simple, and is shown in **Figure 1**. Note that the input capacitor value shown on the schematic is a minimum value – in fact, we used a surface mount 47 uF capacitor here, because we had one to hand. Make sure that this capacitor has a voltage rating big enough to cope with the voltage you intend to use to power the project. Construction details are shown in the illustrated step-by step section of this article.

The software

While the Polyrhythmic Sequencer was written in the Processing language, Python can handle MIDI as well, and we will show you how to do this here. First, you need to load in the real-time MIDI module; it's called RtMidi. It has a few dependences which you may, or may not, already have installed. Into a Terminal window, type:

Figure 2 This screen allows you to test different sounds

```
sudo apt-get install libjack0

sudo apt-get install libjack-dev

sudo apt-get install build-essential

sudo apt-get install libasound2-dev

sudo apt-get install libjack-dev

sudo pip3 install python-rtmidi
```

voiceTest.py

Language
>PYTHON

DOWNLOAD:
magpi.cc/1NqJjmV

PROJECT VIDEOS
Check out Mike's Bakery videos at:
magpi.cc/1NqJnTz

```
001. import pygame, time, os
002. import rtmidi
003.
004. midiout = rtmidi.MidiOut()
005.
006. pygame.init() # initialise graphics
     interface
007.
008. os.environ['SDL_VIDEO_WINDOW_POS']
     = 'center'
009. pygame.display.set_caption("Genral MIDI Instrument
     test")
010. pygame.event.set_allowed(None)
011. pygame.event.set_allowed([pygame.KEYDOWN, pygame.
     MOUSEBUTTONDOWN, pygame.QUIT, pygame.MOUSEBUTTONUP])
012.
013. screenWidth = 1030 ; screenHeight = 530
014. screen = pygame.display.set_mode([screenWidth,screenH
     eight],0,32)
015. textHeight = 18 ; sq = 12 # square size
016. font = pygame.font.Font(None, textHeight)
017. font2 = pygame.font.Font(None, textHeight*4)
018. backCol = (220,200,128) # background colour
019. xList = [5,184,368,542,740,880] # column positions
020. currentVoice = 0 ; currentNote = -1
021. whiteNotes = [48,50,52,53,55,57,59,60,62,64,65,67,69,
     71,72]
022. blackNotes = [49,51,54,56,58,61,63,66,68,70]
023. channel = 0 # change from 0 to 15 use 9 for percussion
024. keyboardShift = 0
025.
026. def main():
027.    print("MIDI Sound Box - Instrument test")
028.    init() # open MIDI port
029.    loadResorces()
030.    drawScreen()
031.    initMIDI()
032.    findBox((10,17)) # hi-light initial voice
033.    while True:
034.       checkForEvent()
035.
036. def loadResorces():
037.     global whiteKeys, blackKeys,iNames,voiceBox
038.     whiteKeys = []
039.     blackKeys = []
040.     voiceBox = []
041.     for i in range(0,15):
042.       whiteKeys.append((280+i*34,420,30,80))
043.     for i in range(0,13):
044.       if not(i ==2 or i == 6 or i == 9):
045.         blackKeys.append((299+i*34,420,26,40))
046.     nameF = open("GM_Instruments.txt","r")
047.     iNames = []
048.     for i in nameF.readlines():
049.        n = i[:-1] # remove CR at end of name
```

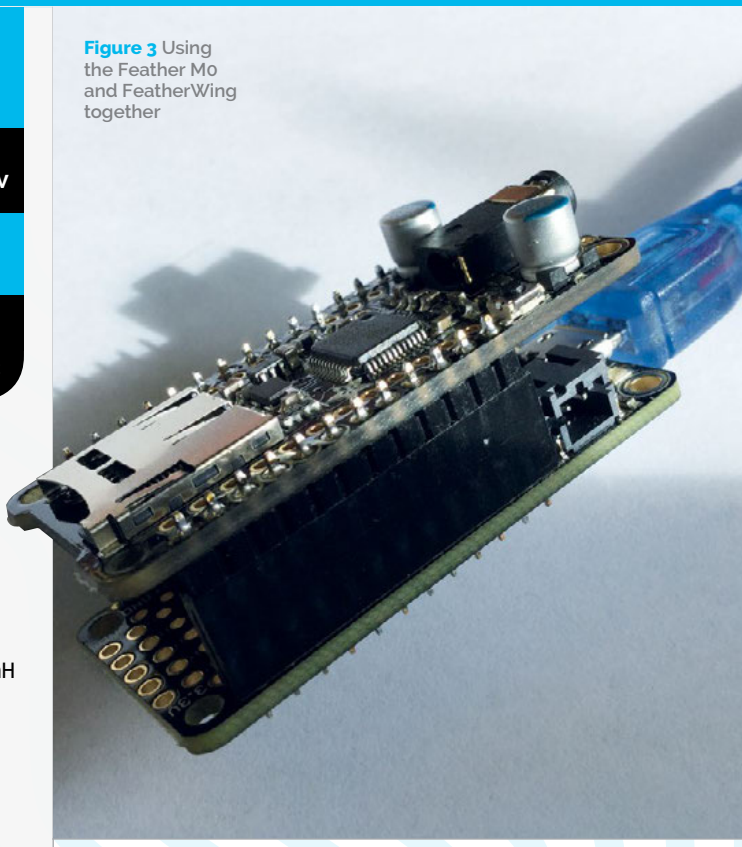


Figure 3 Using the Feather M0 and FeatherWing together

When the installation is complete, reboot and try the **voiceTest.py** program. This displays a small section of a piano keyboard under a list of all 128 different instruments that the chip can produce (**Figure 2**). This is the General MIDI or GM sound set, and is normally implemented on all MIDI sound generators. Click a box to select a sound, and the instrument or voice number is displayed in the lower left-hand corner of the window. The note number on the right changes as you click on the piano keyboard.

This software makes use of a file entitled **GM_Instruments.txt**, which is simply a list of the instrument names in order. You can type this in from the screenshot, but we copied it from the VS1053's PDF data sheet into a text file, then imported it into a spreadsheet using the CSV format. We put the three columns into a single column, and sorted it. Finally, we saved it as a text file and reimported it to the spreadsheet so the numbers were in a separate column, deleted that column, and saved just the instrument names as a text file.

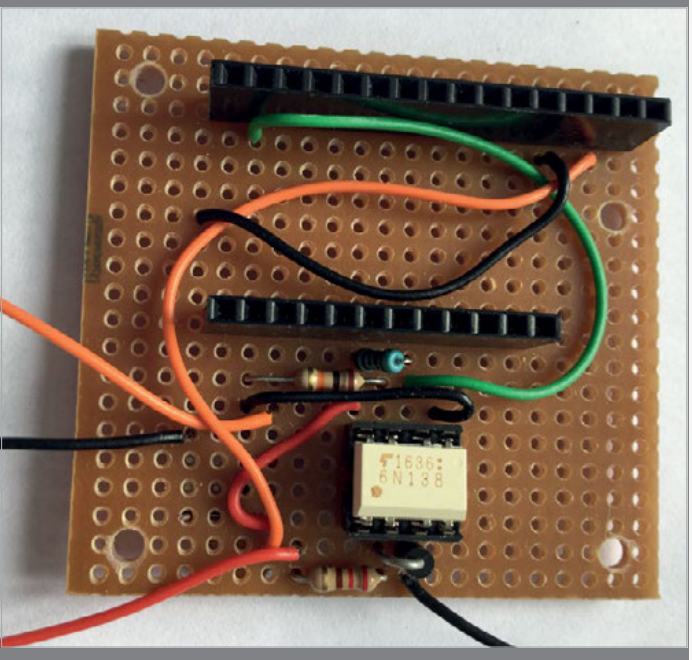
The sound quality

The sounds of the GM set are not the best you've ever heard, but they are far from being the worst. As well as the sound waveform, there are other things that add to the perception of a real instrument: the register, or note range; and the style of playing. For example, a real piccolo only plays high notes, but on a MIDI sound set it can play any note. Some instruments, such as the strumming of a guitar, are

MAKING THE MIDI SOUND BOX

>STEP-01
Making the board

Take a piece of stripboard, 21 by 19 holes (you might want to make it 21 by 20 holes, to give a bit more room to break the tracks between the FeatherWing board and the MIDI input circuitry). Drill holes for mounting, as shown in the photograph. Build the optical isolator MIDI input circuitry, and then add the female headers for the FeatherWing board. Make sure the FeatherWing board just hangs over the end of the stripboard to allow the audio socket to poke through the mounting panel.



not easy to emulate on a keyboard. These differences add up, and your ear picks them up as fake instruments. Nevertheless, the VS1053 makes a good stab at trying to reproduce realistic sounds.

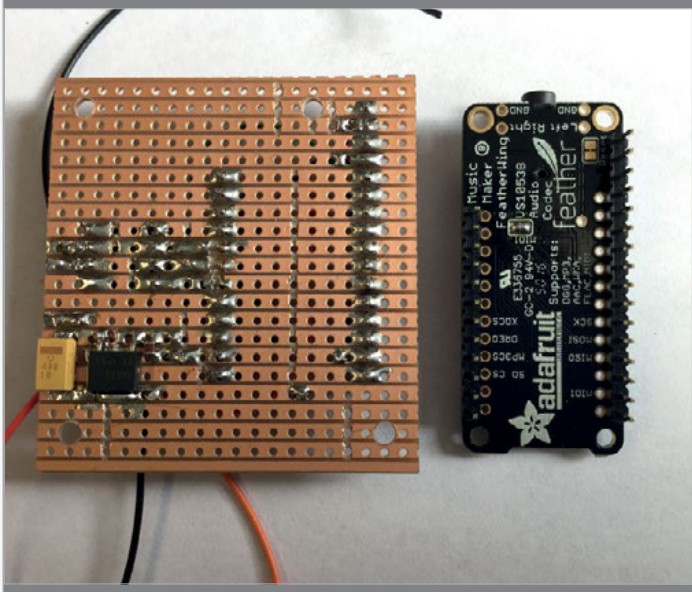
We noticed several problems with the voices. All four saxophone sounds, 84 to 87, were identical, as were the string ensembles 48 and 49. The oboe, voice 69, dramatically changes timbre between note 51 and note 52. Some notes 'develop' when the key is held down for a few seconds, especially voices 88 to 103, and the reverse cymbal, voice 119.

```
050.          iNames.append(n)
051.       nameF.close()
052.       #print(iNames)
053.
054.   def init():
055.      available_ports = midiout.get_ports()
056.      print("MIDI ports available:-")
057.      for i in range(0,len(available_ports)):
058.         print(i,available_ports[i])
059.      if available_ports:
060.          midiout.open_port(1)
061.      else:
062.          midiout.open_virtual_port("My virtual output")
063.
064.   def initMIDI():
065.      midiout.send_message([0xB0 | channel,0x07,127])  # set
      to max volume
066.      midiout.send_message([0xB0 | channel,0x00,0x00]) # set
      default bank
067.
068.   def drawScreen():
069.      cp = screenWidth/2
070.      pygame.draw.rect(screen,backCol,(0,0,screenWidth,screenH
      eight),0)
071.      for i in range(0,len(whiteKeys)):
072.         pygame.draw.rect(screen,(255,255,255),whiteKeys[i],0)
073.      for i in range(0,len(blackKeys)):
074.         pygame.draw.rect(screen,(0,0,0),blackKeys[i],0)
075.      drawLables()
076.      drawWords("Voice",60,400,4)
077.      drawWords("Note",847,400,4)
078.      pygame.display.update()
079.
080.   def updateNote(n): # note displayed
081.      pygame.draw.rect(screen,backCol,(870,462,103,49),0)
082.      if n != -1:
083.         drawWords(str(n),874,460,4)
084.      pygame.display.update()
085.
086.   def updateVoice(n):
087.      pygame.draw.rect(screen,backCol,(87,462,103,49),0)
088.      drawWords(str(n),88,460,4)
089.      pygame.display.update()
         midiout.send_message([0xC0 | channel,n]) # program
090.   change message
091.
092.   def drawWords(words,x,y,s) :
093.           textSurface = pygame.Surface((14*s,textHeight*s))
094.           textRect = textSurface.get_rect()
095.           textRect.left = x
096.           textRect.top = y
097.           if s == 1: # font size
098.              textSurface = font.render(words, True, (0,0,0),
      (20,20))
099.           else:
100.              textSurface = font2.render(words, True, (0,0,0),
      (20,20))
```

```
        screen.blit(textSurface, textRect)

def drawLables():
   for i in range(0,128):
      point = getPoint(i)
      pygame.draw.rect(screen,(0,0,0),(point[0],point
[1],sq,sq),1)
      drawWords(iNames[i],point[0]+20,point[1],1)

def getPoint(index):
    x = xList[ index // 22 ]
    y = 10+(index % 22)*18
    return (x,y)

def findBox(point):
    global currentVoice
    i=0 ; found = False
    while(i<128 and not found):
       testPoint = getPoint(i)
       testRect = pygame.Rect(testPoint[0],testPoint[
1],sq,sq)
       if testRect.collidepoint(point) :
          found = True
       else:
          i += 1
    if found :
       oldPoint = getPoint(currentVoice) # remove
previously checked box
       pygame.draw.rect(screen,backCol,(oldPoint[0],ol
dPoint[1],sq,sq),0)
       pygame.draw.rect(screen,(0,0,0),(oldPoint[0],ol
dPoint[1],sq,sq),1)
       pygame.draw.rect(screen,(200,0,0),(testPoint[0]
,testPoint[1],sq,sq),0)
       updateVoice(i)
       currentVoice = i

def handleMouse(pos):
    #print(pos)
    if pos[0] > 275 and pos[0] < 790 and pos[1]
> 409 :
       i = 0; found = False
       while(i<len(blackKeys) and not found):
          currentRect = pygame.Rect(blackKeys[i])
          if currentRect.collidepoint(pos):
             found = True
          else:
             i +=1
       if found :
          #print("black key number",i)
          playNote(blackNotes[i])
       else :
          i = 0; found = False
          while(i<len(whiteKeys) and not found):
             currentRect = pygame.Rect(whiteKeys[i])
             if currentRect.collidepoint(pos):
                found = True
```

>STEP-02
The underside of the board

Make sure the solder link is made on the back of the FeatherWing board – you can see it next to the 'F' in FeatherWing. Cut the tracks as shown to prevent short circuits, in accordance with the schematic. The regulator we used was a surface-mount type, so we mounted it on this side, along with the 330 nF capacitor on the right, and the 22 uF on the left. The board takes less than 100 mA, so you can easily substitute any other similar fixed voltage regulator in place of the one we used.



Note that this chip is polyphonic, which means that it can play more than one note at once, although the test software will only play one at a time. The chip is capable of processing up to 64 notes at a time, but the data sheet warns that for sustained notes, this number reduces to 40. Pressing the + and – keys will shift the on-screen keyboard up or down by an octave. Note that extremely high or low notes don't sound good on any MIDI system we have heard.

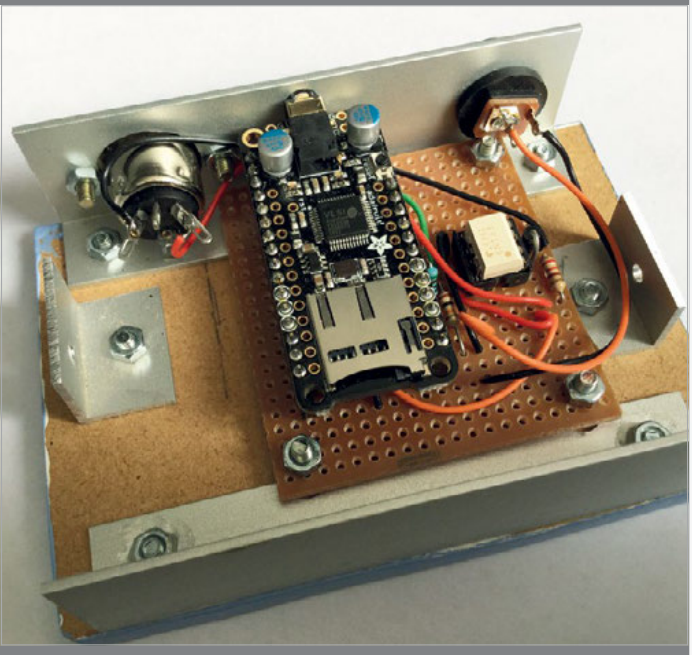
A USB interface

This project uses a conventional MIDI interface, which means you can plug it into any standard interface, including a keyboard. However, this means that you need a USB-to-MIDI lead to connect the MIDI box to your computer. If you want to connect the MIDI sound box directly to your computer, you need to add a processor that can both act as a USB MIDI device, and talk to the VS1053 chip.

An Adafruit Feather M0, or 32u4 processor board with female pin connectors, stacked with a Music Maker FeatherWing, offers an easy solution. The

>STEP-03
Finishing off

Plug in the FeatherWing board and add the 5-pin DIN socket. Connect the input power jack to the flying leads from the board. At this point, test that the board is working correctly. After testing, you can mount it in a box – either a ready-made plastic box, or a home-made arrangement as shown here. We used a Dymo LetraTag label maker, using a clear plastic label cartridge, to label the front panel sockets and the box lid.



only interface is then your USB lead, as shown in **Figure 3**. However, you will need some code to tell the computer to listen to the MIDI. We have written some for you, and it is available in our GitHub repository. As an alternative, the Bare Conductive Touch Board has the same hardware capabilities, and we have written software for that method as well.

Taking it further

Some versions of the Music Maker boards contain amplifiers. You could use one of these to give the project built-in speakers. You need to supply 5 V to drive the amplifier: simply route the regulator input to the Vcc pin of the FeatherWing board.

We will be looking at more applications for this chip next year, but for the time-being, try changing the software so the MIDI box uses channel 9. This brings up a set of percussion sounds instead of the instrumental sets. Note that sounds are only generated for note numbers between 27 and 87. Check page 33 of the VS1053 data sheet for a list of available sounds.

```
151.                else:
152.                   i +=1
153.             if found :
154.                #print("white key number",i)
155.                playNote(whiteNotes[i])
156.       if pos[1] < 409 :
157.          findBox(pos)
158.
159.  def playNote(note):
160.     global currentNote
161.     note += keyboardShift
162.     note = note  & 0x7F
163.     if note != currentNote:
164.        midiout.send_message([0x90 | channel,note,68]) #
      channel 1, note, velocity 68
165.        currentNote = note
166.        updateNote(note)
167.
168.  def terminate(): # close down the program
169.       global midiout
170.       print ("Closing down please wait")
171.       del midiout
172.       pygame.quit() # close pygame
173.       os._exit(1)
174.
175.  def checkForEvent(): # handle events
176.       global currentNote, keyboardShift
177.       event = pygame.event.poll()
178.       if event.type == pygame.QUIT :
179.            terminate()
180.       if event.type == pygame.KEYDOWN :
181.          if event.key == pygame.K_ESCAPE :
182.             terminate()
183.          if event.key == pygame.K_EQUALS :
184.             keyboardShift += 12 # move up an octave
185.             if keyboardShift > 55 :
186.                keyboardShift -= 12
187.             print("Shift",keyboardShift // 12, "octaves")
188.          if event.key == pygame.K_MINUS :
189.             keyboardShift -= 12 # move up an octave
190.             if keyboardShift < -48 :
191.                keyboardShift += 12
192.             print("Shift",keyboardShift // 12, "octaves")
193.          if event.key == pygame.K_s : # screen dump
194.             os.system("scrot")
195.       if event.type == pygame.MOUSEBUTTONDOWN :
196.           handleMouse(pygame.mouse.get_pos())
197.       if event.type == pygame.MOUSEBUTTONUP :
198.          if currentNote != -1:
199.             midiout.send_message([0x80 |
      channel,currentNote,0])
200.             currentNote = -1 # no note playing
201.             updateNote(currentNote)
202.
203.  # Main program logic:
204.  if __name__ == '__main__':
205.       main()
```

KENT ELCHUK

A Raspberry Pi enthusiast, web developer and multi-published gardening author who is likely coding, gardening or doing family stuff.
growlode.com

SET UP AND MONITOR A HYDROPONIC GARDEN

You'll Need

- Motion **magpi.cc/2gVrlp2**
- USB webcam
- Remote hosting account (e.g. GoDaddy, Bluehost, HostGator)

Follow up last month's tutorial with everything you need to know to build a hydroponic garden

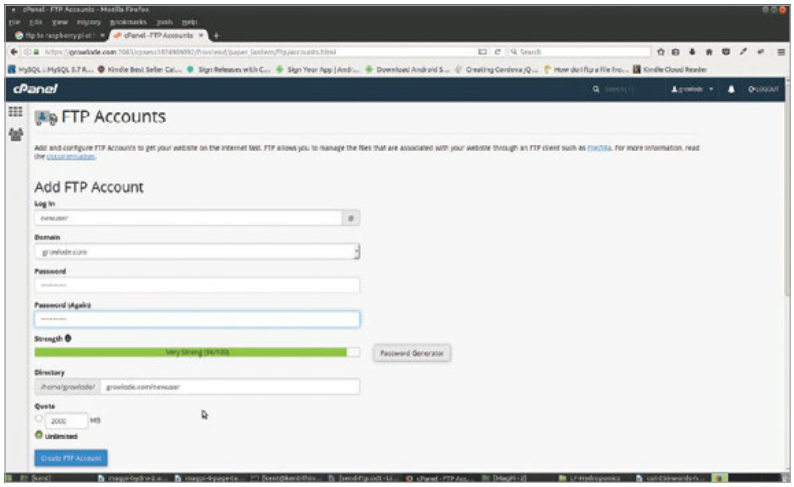
PART 02

In the modern era, with urban farming and increasing food costs, it's time to take charge and build affordable hydroponic gardens for everyone's favourite produce: lettuce, tomatoes, peppers, onions, jalapeños, and cucumbers, to name a few. With a Raspberry Pi at each garden location, a quick automatic snapshot can be taken and the image sent to that user's account on a remote server. The remote server admin can easily display those images from each account into a password-protected webpage and watch every garden from anywhere on the planet. When something looks off, a garden can be checked and fixed.

Last month, we learned to use a sensor to monitor the watering of a garden and access that information over the web. This time around, we're going to look at remote garden monitoring using a webcam and expand on the actual gardening part.

By the end of this tutorial, hooking up Raspberry Pis with USB webcams to more than one garden location and keeping an eye on the progress of all gardens will be as easy as one-two-three.

Let's dive into the monitoring aspect, as it is very crucial – seeing is believing. Unlike the previous lesson about water sensors, a webcam helps you monitor for other potential issues like wind damage, plants in need of extra support and the pure pleasure of watching beautiful gardens over which we have complete control.



Below Setting up a FTP user account is fast and simple; just provide the basics like user name and password. This info will be added to the send.sh script on a user's Raspberry Pi

Plant monitoring

In a nutshell, plant monitoring is performed with the Motion package for Linux. In the previous tutorial (**magpi.cc/2zbzZ6Y**), all the setup and configuration was explained in precise detail, so refer to that when needed. You will be able to do this for information regarding installing Linux Motion, setting permissions to folders, and testing it with a browser.

Remote file transfer

There are various means with which files can be transferred from the Raspberry Pi to the remote server; SCP, FTP, SFTP, FTPS, to name just a few. If we keep things simple and manage both servers with a single admin, any of these methods are good to use.

On the other hand, if we plan to have cameras from various foreign networks and want all the images on

the same remote server, that takes more work. To do that, we can create FTP accounts for each Raspberry Pi monitoring a remote garden. Then, each Pi will authenticate and upload the file to its own account.

In the case of multiple machines, each unit will need its own user name and password and the file will be transferred with the **curl** command. That's about it, because once the server interprets the user name and password, it already knows which folder will receive the file.

Since the monitoring is intended to be automated, cron jobs can be used to make sure the command runs at the desired time. In the example crontab file code below, we can see a list of the various means by which the files can go from point A to point B.

All cron jobs listed below run each minute. The first three commands send the **lastsnap.jpg** file. Notice how the first command actually runs a file that has the command, while the others are commands.

Before we go too much further, let's take a look the first command, which is a basic FTP transfer. We can make a file called **send.sh** and give it executable rights. The rest just takes care of itself.

The **chmod +x /var/lib/motion/send.sh** command will make the file executable. Meanwhile, the code is included with this tutorial and all you have to change is the FTP host, username, and password.

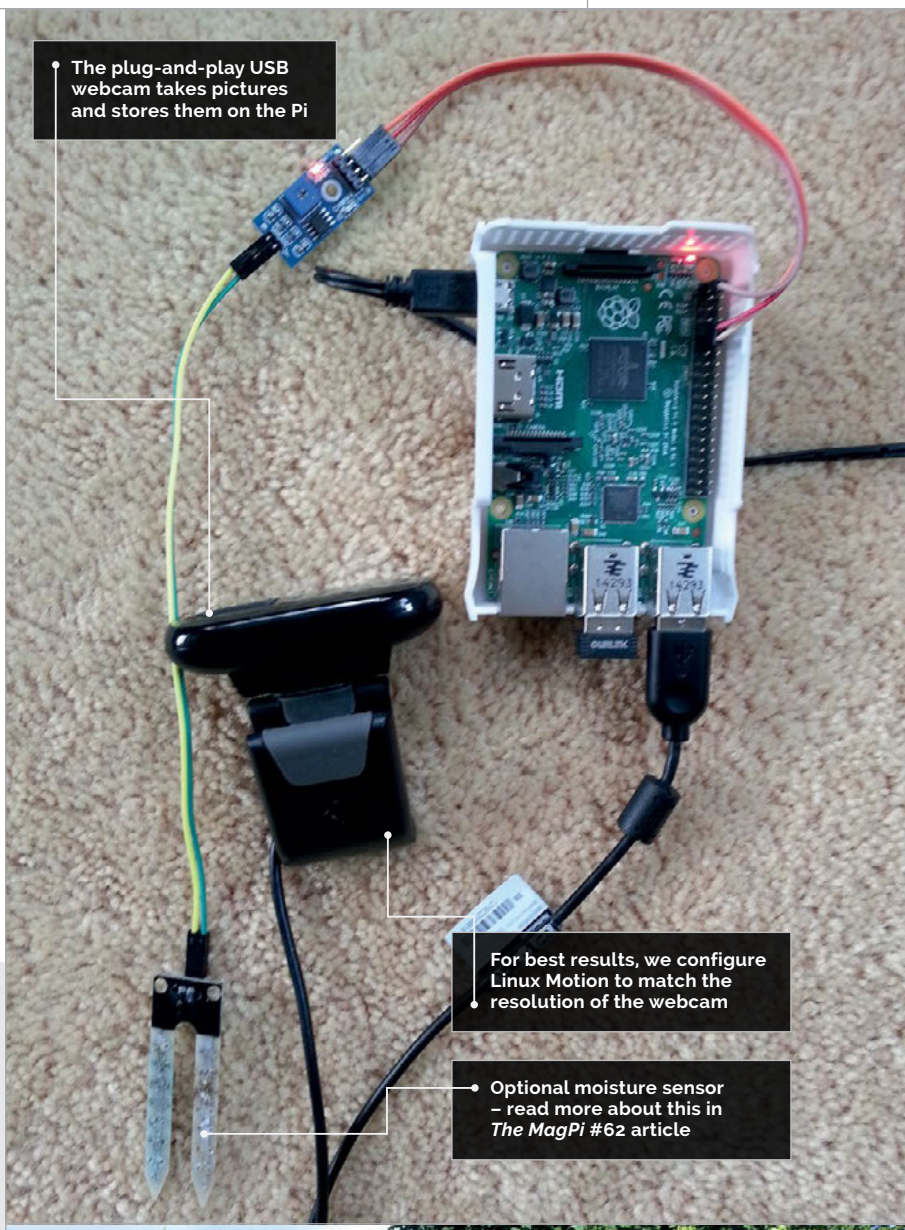
Moving on, let's take a look at the other methods.

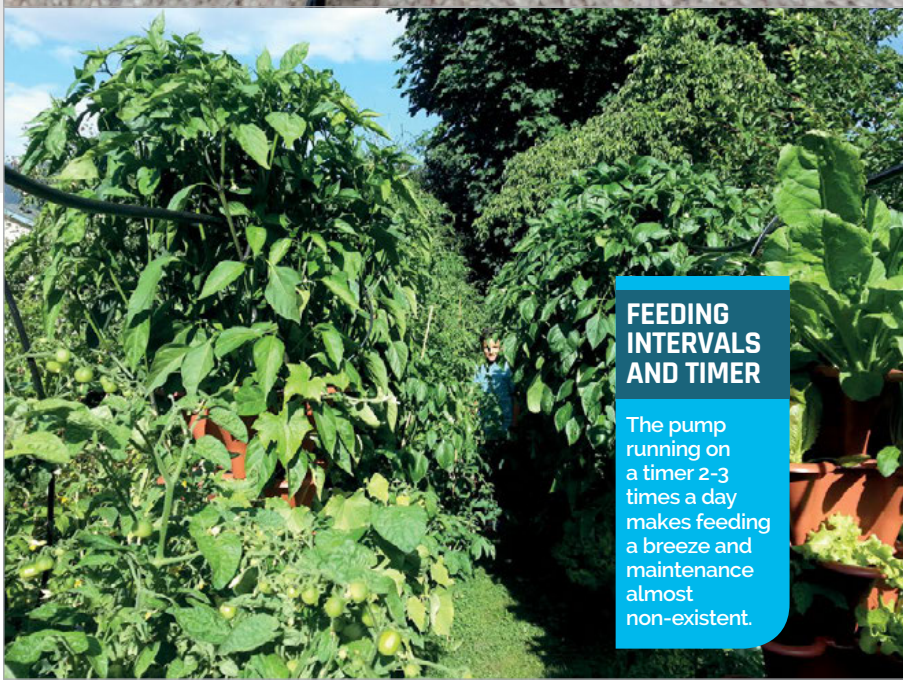
```
*/1 * * * * /var/lib/motion/send.sh > /
dev/null 2>&1

*/1 * * * * /usr/bin/curl --ftp-ssl
-T "/var/lib/motion/lastsnap.jpg" -k -u
"member@members.growlode.com@growlode.
com:MemberPassword" "ftp://growlode.com"

*1/ * * * *  scp /var/lib/motion/lastsnap.
jpg pi@ipaddress:/tmp

*/1 * * * * scp -r /var/lib/motion pi@
ipaddress:/tmp
```

The last command in our crontab list sends the entire folder, which can pile up as there is a new pic every 100 seconds. The other examples only send the **lastsnap.jpg** file which continually overwrites the previous one, therefore no files pile up and each user account only stores a few kilobytes.

However, while sending the entire directory would be a nice 'see all', it may not be practical as you will likely want to remove excess files at some point.

Now that we have covered the details regarding how a Raspberry Pi can send images to a remote server, let's look a little into the remote server itself. Although the remote server could be another Raspberry Pi on a home internet connection, using a web hosting account would be the way to go.


The plug-and-play USB webcam takes pictures and stores them on the Pi
For best results, we configure Linux Motion to match the resolution of the webcam
Optional moisture sensor – read more about this in *The MagPi* #62 article



FEEDING INTERVALS AND TIMER

The pump running on a timer 2-3 times a day makes feeding a breeze and maintenance almost non-existent.

WEBCAM RESOLUTION

Linux Motion allows you to match the resolution of the webcam. Thus, more pixels will allow for larger, clearer images; even those taken from indoors.

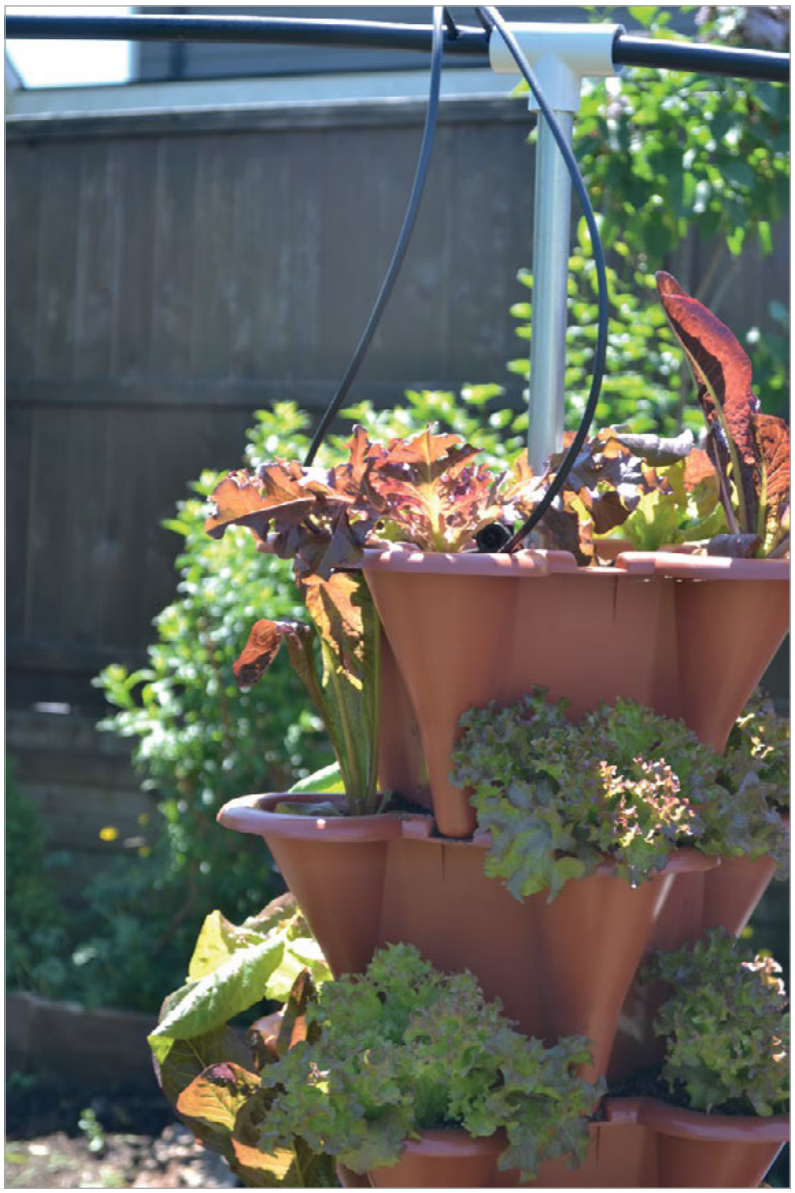
For starters, web hosting is cheap, up and running more than 99.99% of the time, and is configured to work fine even with multiple FTP accounts. If we choose a plan that includes cPanel, life is real easy.

When FTP is used with a hosting account, all we have to do is create an FTP user and password. All this is done with a simple GUI. To do this with cPanel, we log in and click 'FTP Accounts'.

After that, we add a user name and password and create the user. The information for the user, such as the host, user name and password, is modified in the **send.sh** file we created. Those credentials for each user will be specific to each Raspberry Pi that monitors gardens.

Another benefit of web hosting is that when we have an issue, technical support is only a phone call away.

The downside of using a home web server to be the mother machine is that we must alter router port forwarding settings for receiving files via FTP and server reliability.



Below The ¼-inch feeder lines are connected to the ½-inch header line with ¼-inch barbed fittings. The other end is connected to a dripper

Hydroponic system setup

Last time around, some system feeding and basics were covered. This time, we dive right into a 50-pot setup, which is plenty to feed a small family.

To start off, we buy the following list of items:

50 × quad pots
50ft roll of ½-inch poly tubing
100ft roll of ¼-inch poly tubing
20 × 2 gallon-per-hour drippers
550 gallon-per-hour pump
55-gallon reservoir
1 × ¾-inch through-hull fitting
5 × ½-inch PVC elbows
1 × ½-inch PVC end cap
1 × line punch
10 × 8ft lengths of ¾-inch electrical conduit pipe
10 × 18-inch pieces of 1.5-inch schedule 40 PVC
40 × 6-7 inch lengths of 1-inch PVC spacers for each pot, depending on manufacturer
1 × fence post pounder
10 × 3-gallon round nursery pots
soilless mix or coco coir
10 × 2 by 6 wood squares
20 × plant stakes
10 × 1-inch PVC Ts

The first step is to pound the fence posts 2 ft (61 cm) deep at a spacing of 4 ft (122 cm) centres. We will have two rows of five posts.

After that, we cut holes in 2×6 wood and the 3-gallon pots with a 1-inch holesaw or spade bit, and put them over the pipe until they are on the bottom, with the wood being first and the pot second. Then, the 1.5-inch PVC pipe is placed over top of the steel pipe. Keep in mind that mitre saws make perfect cuts for wood and all PVC.

Now, it's time to add the pots. The first quad pot is strung through the pipe until it lands on top of the 1.5-inch PVC pipe. Larger pots may need spacers between each pot. Thus, we put the 6-7 inch spacers made from 1-inch PVC over the pipe until it goes to the bottom of the pot. The spacer fits at a height so the next stacked pot locks with the one below, yet has support from the spacer in the middle section.

After the spacer, we add medium to each pot before the next pot is stacked on top. We repeat the process for each pot until the fifth pot on top. Pot #5 will not need a spacer. After repeating this process with each tier, we have a system with pots and medium. Now, we need to set up irrigation.

We now take the blue tank and move it to one end between both pipes. We cut a hole near the top of the tank and insert a through-hull fitting with the extended end outside the tank. Then, we connect the pump to ½-inch tubing with a ½-inch PVC elbow at the far end from the pump.

Above Setup showing pipes with bottom pots, PVC supports, pots and medium, and header lines

We then attach another piece of ½-inch PVC to the elbow on one end and to the through-hull fitting on the other side. After that, we connect a small 6-inch piece of ½-inch tubing to the through-hull fitting followed by another ½-inch PVC elbow.

Then, we add ½-inch hose to the elbow until it reaches the first steel pipe. Now, we add another elbow and run a long line of ½-inch PVC along the top and through 1-inch PVC Ts that are placed on top of each pipe.

At the end of the first row, we add another ½-inch poly elbow followed by a single ½-inch poly that runs about 4 ft to the other row. This 4 ft length also has an elbow attached that will point towards the second row of pipes. Then, another long line runs through 1-inch PVC Ts that are placed on the tops of the second row of pipes. At the very end (which is back where the tank is), we add a ½-inch PVC end cap. The header line is done.

Finally, two holes are punched in the line above each column and they are filled with ¼-inch barbed fittings that are connected to ¼-inch tubing that runs to the top pot. At the ends of the ¼-inch lines are a dripper. These lines are supported with plant stakes.

send.sh

Language

>BASH

DOWNLOAD:
magpi.cc/2y3W7D2

```
#!/usr/bin/env bash

PASSWORD=MemberPassword1

HOST='ftp.growlode.com'
USER='member@members.growlode.com'
FILE='lastsnap.jpg'

cd /var/lib/motion
ftp -n $HOST <<END_SCRIPT
quote USER $USER
quote PASS $PASSWORD
binary
put $FILE
quit
END_SCRIPT
exit 0
```

CRON JOBS

Cron jobs allow you to run a command or script at any time and interval you please.

WATERING AND FERTILIZING

Mixing dry fertilizer (always much cheaper than liquid) the night before allows the solution to mix well and raise the water temperature from cold, tap water. Optimal temp is 18°C (65°F) to 27°C (80°F).

Enjoy your work

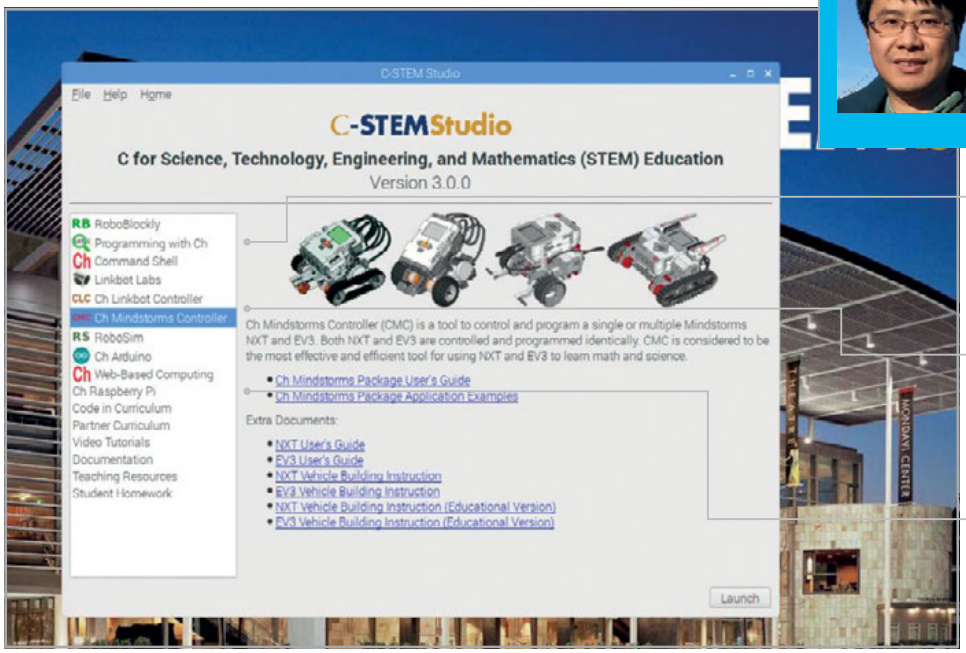
We now have the tools and techniques to build a garden monitor and view the status from anywhere in the whole wide world.

Believe it or not, we can now easily make trips out of town and have our daily timer set at the proper feeding intervals, and enjoy that long weekend without wondering about the unknown.

Happy remote gardening!

BINSEN QIAN

Binsen Qian is a PhD candidate in Mechanical Engineering at University of California, Davis, and Research Associate at the UC Davis C-STEM Center.
magpi.cc/2xEGEa9


C-STEM Studio
File Help Home
C-STEMStudio
C for Science, Technology, Engineering, and Mathematics (STEM) Education
Version 3.0.0
RB RoboBlockly
Programming with Ch
Ch Command Shell
Linkbot Labs
CLC Ch Linkbot Controller
CMC Ch Mindstorms Controller
RS RoboSim
Ch Arduino
Ch Web-Based Computing
Ch Raspberry Pi
Code in Curriculum
Partner Curriculum
Video Tutorials
Documentation
Teaching Resources
Student Homework
Ch Mindstorms Controller (CMC) is a tool to control and program a single or multiple Mindstorms NXT and EV3. Both NXT and EV3 are controlled and programmed identically. CMC is considered to be the most effective and efficient tool for using NXT and EV3 to learn math and science.
Ch Mindstorms Package User's Guide
Ch Mindstorms Package Application Examples
Extra Documents:
NXT User's Guide
EV3 User's Guide
NXT Vehicle Building Instruction
EV3 Vehicle Building Instruction
NXT Vehicle Building Instruction (Educational Version)
EV3 Vehicle Building Instruction (Educational Version)
Launch

Programming with Ch will launch ChIDE, which supports all the programming for your robot

Ch Mindstorms Controller will launch an interactive GUI for connecting to and controlling your robots

Ch Raspberry Pi will launch a simple GUI to interact with the GPIO pins

CONTROLLING LEGO MINDSTORMS ROBOTS WITH A RASPBERRY PI

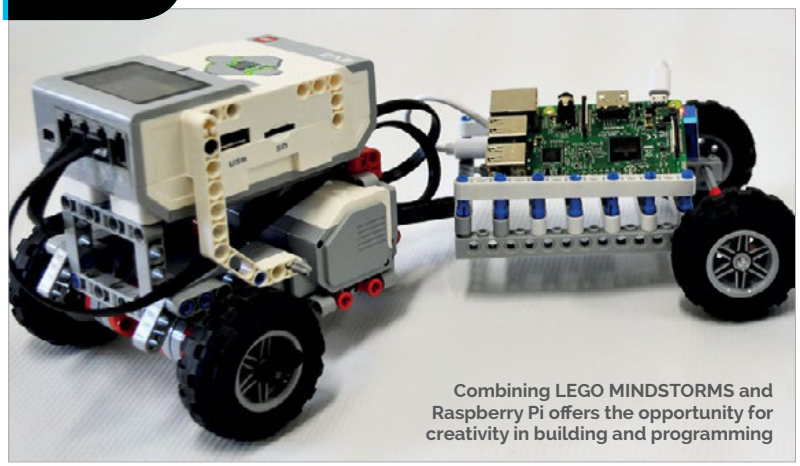
Discover an alternative and user-friendly platform to control multiple MINDSTORMS robots

You'll Need

- C-STEMbian OS **magpi.cc/2p3JUNP**
- A monitor or display
- MINDSTORMS NXT/EV3 robots (up to seven)

In this tutorial, you will find the tools you need to easily connect to your robots, and a variety of options for programming and controlling them. Interfacing LEGO MINDSTORMS robots with Raspberry Pi is made easy thanks to the Ch Mindstorms Controller (CMC). The C-STEM Center at UC Davis has developed C-STEM Studio with CMC to provide a simple-to-use platform for 4- to 19-year-old students to learn Computing, Science, Technology, Engineering, and Maths with LEGO MINDSTORMS NXT and EV3 robots.

C-STEM Studio is a user-friendly platform that allows you to control LEGO MINDSTORMS NXT and EV3 robots directly from a Raspberry Pi. A single program can also control multiple NXT/EV3 robots at the same time. This tutorial will guide you through the steps of installing the software, connecting to your robots, and controlling them.

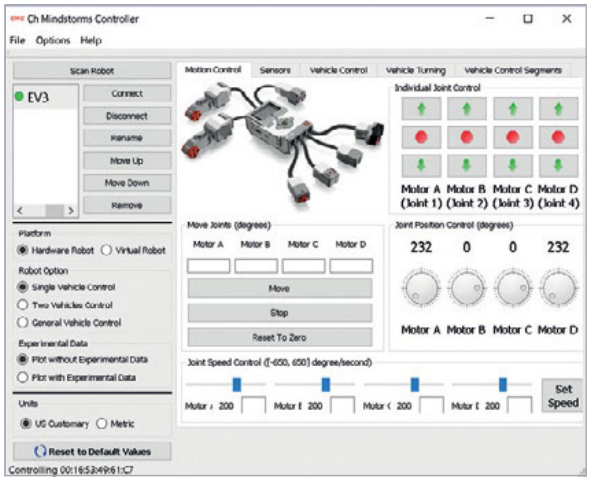


Combining LEGO MINDSTORMS and Raspberry Pi offers the opportunity for creativity in building and programming

Software

In order to connect to your MINDSTORMS robot from the Ch Mindstorms Controller, you will need access to the C-STEM Studio platform. We recommend downloading and installing C-STEMbian, a free open-source Linux operating system for Raspberry Pi. C-STEMbian is a superset of Raspbian, and includes several tools that provide a user-friendly environment for computing, robotics, and cyber-physical systems.

If your Raspberry Pi is already running Raspbian, you can install the C-STEM software modules individually. All the necessary software, including



Above The Motion Control panel features many options for individual motor control, and displays information about the current positions of each motor

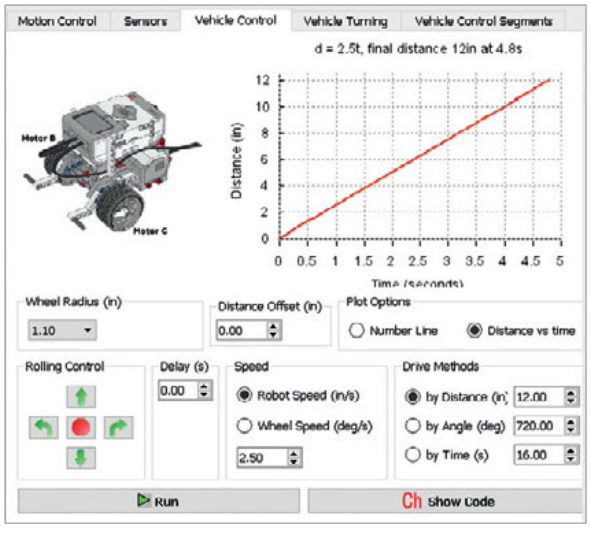
C-STEMbian, is available from the C-STEM website (**magpi.cc/2p3JUNP**), along with instructions to guide you through the installation process, and to help you connect to your Raspberry Pi.

Connecting to your MINDSTORMS robot(s)

Connecting to your MINDSTORMS robot is simple with the C-STEM software.

Open C-STEM Studio and launch the Ch Mindstorms Controller. Ch Mindstorms Controller can connect with both EV3 and NXT robots. Simply press the Scan Robot button, then add the robots that are found to the list on your robot manager. Follow the instructions on screen to pair the robots with your Raspberry Pi, and add the robots you want to work with. Do make sure that the robots are turned on and have Bluetooth enabled.

Once the robots have been scanned and added to the list, select the ones you would like to connect to and press Connect. Robots to which you are connected will have a green dot next to their names.



Above The Vehicle Control panel provides options for driving by distance, angle, and time, and can plot the resulting data

group_fourMindstorms.ch

Language
>C/C++

DOWNLOAD:
magpi.cc/2yaWpbX

```
/* Control multiple robots simultaneously
using the CMindstormsGroup class*/

#include <mindstorms.h>
CMindstorms robot1, robot2, robot3, robot4;
CMindstormsGroup group;

double radius = 1.1; // radius of the wheels (inches)
double trackWidth = 4.54; // track width of the robots (inches)

/* add the four robots as members of the group */
group.addRobot(robot1);
group.addRobot(robot2);
group.addRobot(robot3);
group.addRobot(robot4);

group.driveDistance(5, radius); // drive robots forward 5 inches
group.turnLeft(90, radius, trackWidth); // turn robots left 90
degrees
group.driveDistance(10, radius); //drive robots forward 10 inches
```

Controlling your MINDSTORMS robots

Once you are connected to your robot, the CMC offers many options for control.

Real-time control

Using the Motion Control panel, you can rotate individual motors continuously, move motors by given angles, and drag and drop motors into a desired angle. You can also set the speed of each motor at any time.

Monitor sensor data

Use the Sensors panel to monitor the sensors attached to the robot. You can set sensors to different modes, and the values from the sensors will update automatically.

Educational features

In the other panels we introduced some educational features, designed to help students learn mathematical concepts. For example, in the Vehicle Control panel, a student controls a robot configured as a vehicle. Students can set the vehicle's wheel size and speed, and drive the vehicle by distance, by angle, or by time. The robot then drives as programmed, and a graph of distance versus time is plotted. With these features, students can learn about number lines, linear relationships, and the concept of pi.

Program robots in C/C++ interpreter Ch

To program the robots, you need to keep them connected in the controller, then open ChIDE and start programming. You can program up to seven robots, which is hard to do using other platforms.

PROGRAMMING IDEAS AND HELP

Open the Learn Mindstorms folder in the Code in Curriculum section of C-STEM Studio to find Ch programs for MINDSTORMS.

ADVANCED APPLICATIONS

Explore the Demos folder (in Code in Curriculum) for additional examples and applications using sensors, Linkbots, and different robot configurations.

MATHS ON THE RASPBERRY PI

Ditch the calculator and get your Raspberry Pi to do your sums

You'll Need

- Raspberry Pi
- Raspbian

Your Raspberry Pi is an amazing tool for learning maths and working with mathematical equations.

In fact, we've stopped using calculators for maths problems, and started using our Raspberry Pi instead; and we think Maths on a Pi it's a great thing to learn.

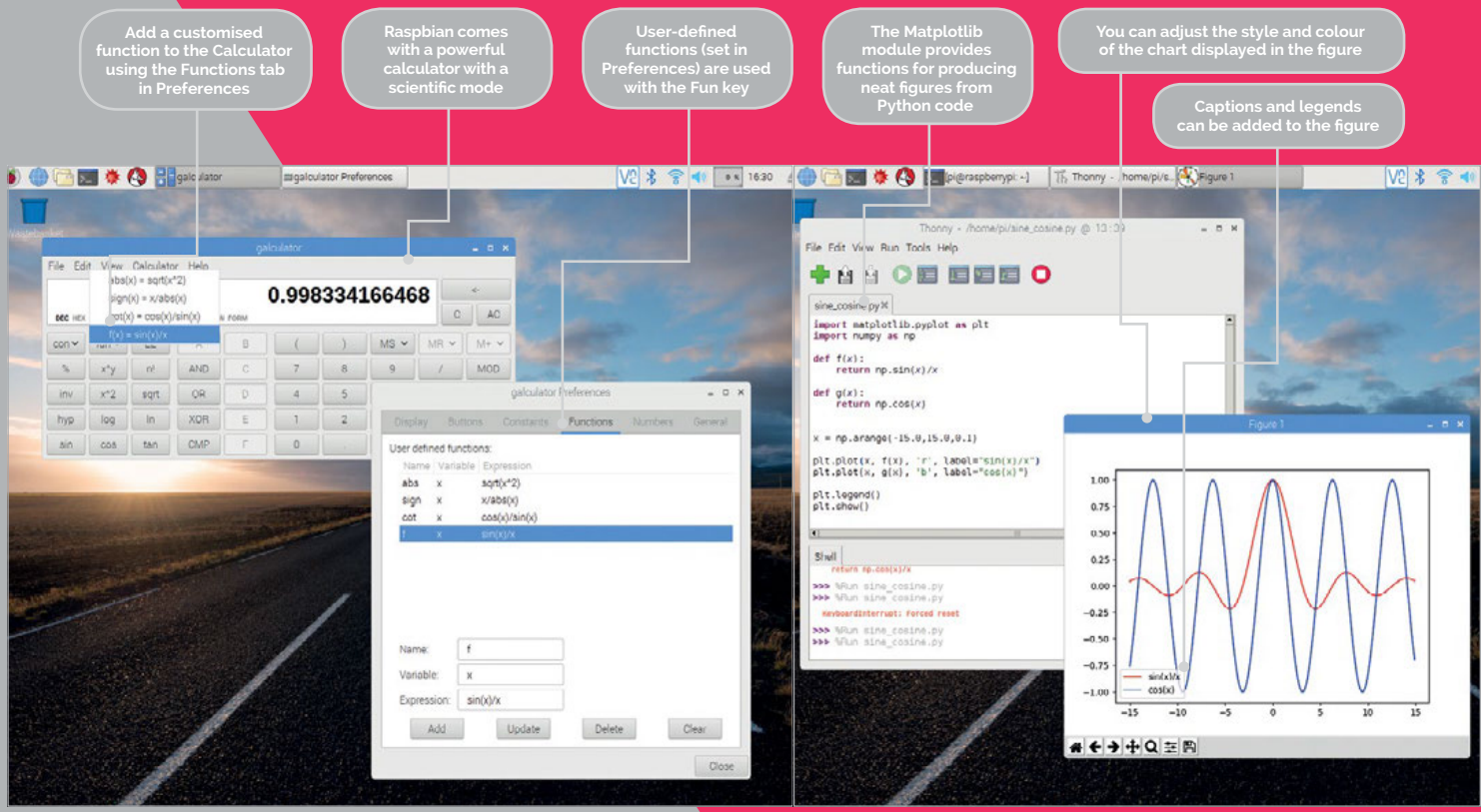
One of the best ways to understand a maths problem is to program a computer to solve it. And solving maths problems is a great way to practise programming. It's a win-win!

The stock version of Raspbian comes with a calculator app built in: officially it's GCalculator, but marked as just 'Calculator' in the interface.

Calculator is used in Basic and Scientific Mode. In Scientific Mode it also has a handy 'Fun' key that can be used to implement user-defined functions.

Powerful though Calculator is, a far more versatile option is Python. You can access Python in a Terminal window, or by using one of the Python IDE (integrated development environment) apps. Our current favourite is Thonny, which we'll use for most of this tutorial.

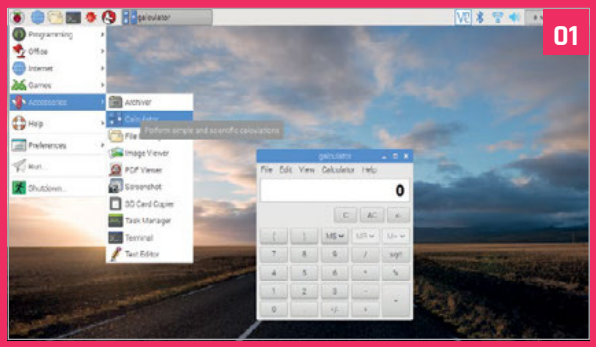
In this guide we'll look at using Calculator and Python to perform calculations, and graph functions using Matplotlib and NumPy, two popular Python modules.


Add a customised function to the Calculator using the Functions tab in Preferences
Raspbian comes with a powerful calculator with a scientific mode
User-defined functions (set in Preferences) are used with the Fun key
The Matplotlib module provides functions for producing neat figures from Python code
You can adjust the style and colour of the chart displayed in the figure
Captions and legends can be added to the figure
0.998334166468
User defined functions:
Add
Update
Delete
Clear
Close

HOW TO: SOLVE MATHS PROBLEMS WITH YOUR RASPBERRY PI

>STEP-01
Calculator

If all you want to do is run a few sums, then the Calculator app (Menu > Accessories > Calculator) is a good call. Click the buttons with a mouse or use your keys on the keyboard. Under View you'll see three options: Basic Mode, Scientific Mode, and Paper Mode (a text entry mode that is useful for keeping track of previous calculations).

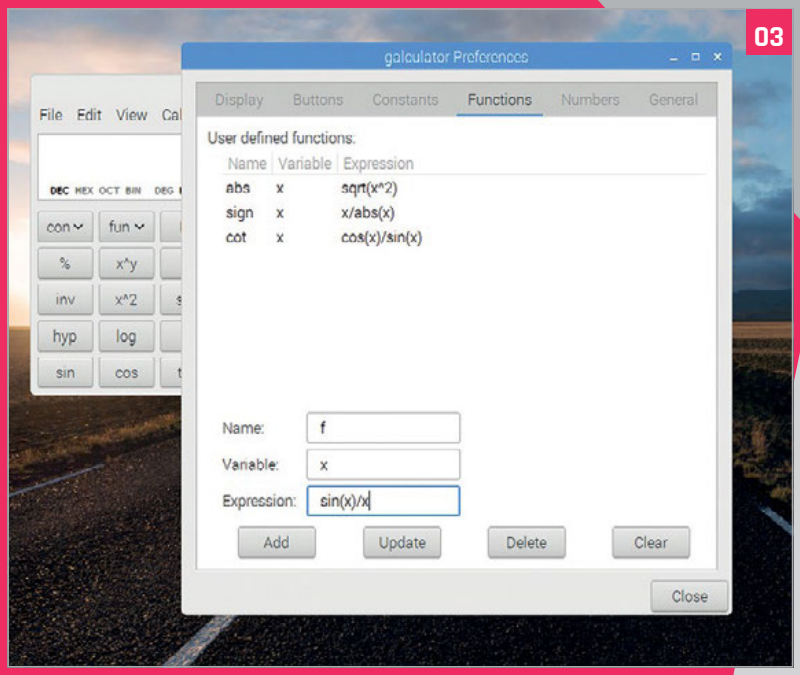


>STEP-02
Functions

One neat trick with the Calculator app is the Fun key. This enables you to apply functions to numbers. There are three functions included by default. The first, abs(x)=sqrt(x^2), returns the positive value for any number. Enter 2 and press the +/- key to set it to negative. Now click Fun and choose abs(x)=sqrt(x^2) to convert it to positive.

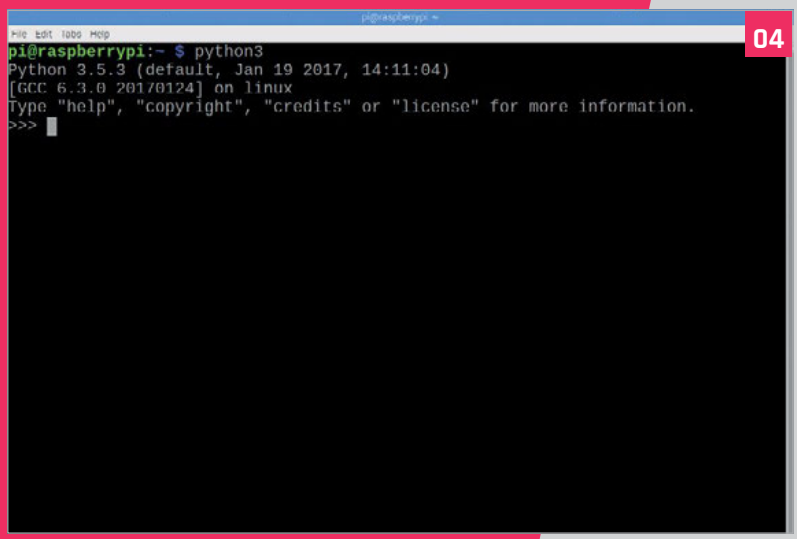
>STEP-03
Create functions

You can create functions using Edit > Preferences and choosing the Functions tab. Suppose you're being asked to find the limit of sin(x)/x as x approaches 0. Rather than working out sin(x)/x for each number, you can create a function. Enter 'f' in the Name field, 'x' in the Variable field, and sin(x)/x in the Expression field. Click Add and Close to create the function. Now enter values in the calculator, such as 0.1, 0.01, 0.001. Click Fun and choose the f(x) function to work out the result.



>STEP-04
Switch to Python

While Calculator is a great app, it offers no real advantage over a good scientific calculator. Python, on the other hand, is a powerful programming language with a huge amount of maths support built in. You can quickly access Python in interactive mode from the Terminal app: just enter **python3** to switch to interactive mode for Python 3.


04
pi@raspberrypi:~ $ python3
Python 3.5.3 (default, Jan 19 2017, 14:11:04)
[GCC 6.3.0 20170124] on linux
Type "help", "copyright", "credits" or "license" for more information.
>>>

05

```
pi@raspberrypi:~ $ python3
Python 3.5.3 (default, Jan 19 2017, 14:11:04)
[GCC 6.3.0 20170124] on linux
Type "help", "copyright", "credits" or "license" for more information.
>>> 2 + 2
4
>>>
```

06

```
pi@raspberrypi:~ $ python3
Python 3.5.3 (default, Jan 19 2017, 14:11:04)
[GCC 6.3.0 20170124] on linux
Type "help", "copyright", "credits" or "license" for more information.
>>> 2 + 2 * 4
10
>>>
```

07

```
pi@raspberrypi:~ $ python3
Python 3.5.3 (default, Jan 19 2017, 14:11:04)
[GCC 6.3.0 20170124] on linux
Type "help", "copyright", "credits" or "license" for more information.
>>> 2 + 2 * 4
10
>>> (2 + 2) * 4
16
>>>
```

08

```
pi@raspberrypi:~ $ python2
Python 2.7.13 (default, Jan 19 2017, 14:48:08)
[GCC 6.3.0 20170124] on linux2
Type "help", "copyright", "credits" or "license" for more information.
>>> 9 / 2
4
>>> exit()
pi@raspberrypi:~ $ python3
Python 3.5.3 (default, Jan 19 2017, 14:11:04)
[GCC 6.3.0 20170124] on linux
Type "help", "copyright", "credits" or "license" for more information.
>>> 9 / 2
4.5
>>>
```

>STEP-05

Enter calculations

It's possible to enter calculations directly into the Python interactive shell. If you enter '2 + 2' then you will get the answer, '4'. In the interactive shell you don't need to pass calculations through the `print()` function (although you do when scripting a program).

>STEP-06

Operator precedence

One thing that may well trip you up is operator precedence. If you enter 2 + 2 * 4 on many basic calculators, you'll get 16. Enter the same sum in Python (or many scientific calculators) and you'll get 10. This is because Python performs multiplication before addition. So it works out 2 * 4 = 8; then 2 + 8 = 10. It does this according to PEMDAS rules (see the 'Order of operations' box, page 59).

>STEP-07

Parentheses

To take control of your operations, you need to include parentheses around the items you want to work on first. To add our 2 + 2 together, then multiply that sum by four, we'd write:

```
(2 + 2) * 4
```

Parentheses have the highest order of operation in any equation, overriding everything else. You can nest parentheses inside equations, adjusting which parts are worked on first. All of these give different results:

```
2 + 2 * 2 ** 2 = 10

(2 + 2) * 2 ** 2 = 16

2 + (2 * 2) ** 2 = 18

((2 + 2) * 2) ** 2 = 64
```

Experiment with parentheses until you get the hang of it. For more details on order of operations, visit this TutorialsPoint page: **magpi.cc/2hMl7IC**.

>STEP-08

Integer vs float

Numbers in Python are not all equal. The number 1 is not the same as the number 1.0. Even though they have the same value, they are a different type. The number 1 (without a decimal point) is an **integer**; the number 1.0 is a **float**.

If you're using Python 3, then most of the time this doesn't matter. But if you're using regular Python 2 then it does, because in Python 2 these two sums return different results.

```
9 / 2 = 4

9.0 / 2 = 4.5

9 / 2.0 = 4.5
```

What gives? In Python 2, an integer is a whole number and dividing 9 / 2 returns an integer (a whole number). And rather than round up the .5 at the end, it's simply truncated (removed), leaving you with 4.

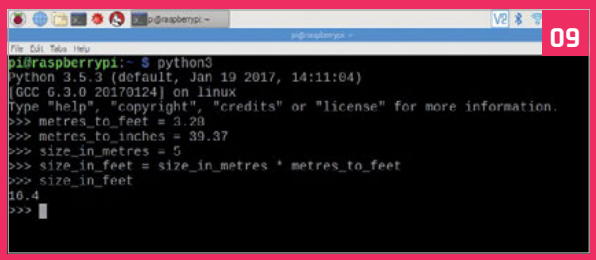
If you divide a float by an integer (or an integer by a float) then Python 2 automatically returns a float, giving you the precise answer.

In Python 3, though, things are a little more sensible. Python 3 returns a float for all equations that contain a division symbol.

```
9 / 2 = 4.5
```

You can see this in Python using the **type()** function:

```
type(2 + 2) # returns <class 'int'>

type(2 / 2) # returns <class float>
```



>STEP-09

Storing numbers

Another advantage Python has over many calculators is the ability to quickly store numbers as variables. These can then be reused in your calculations. For example, there's approximately 3.28 feet in a meter, or 39.37 inches.

```
metres_to_feet = 3.28

metres_to_inches = 39.37

5 * metres_to_feet = 16.4

5 * metres_to_inches = 196.85
```

You can even store your variables and answers as other variables:

```
size_in_metres = 5

size_in_feet = size_in_metres * metres_to_feet

size_in_feet
```

Language
>PYTHON

DOWNLOAD:
magpi.cc/MathsPython

f.py

```
import math

def f(x):
    return math.sin(x)/x

values = [0.1, 0.01, 0.001, 0.0001]

for val in values:
    print(f(val))
```

sine_function.py

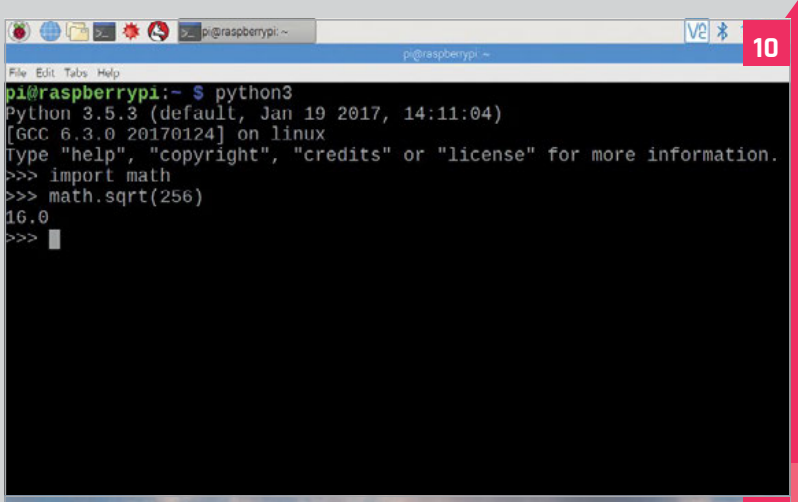
```
import matplotlib.pyplot as plt
import numpy as np

def f(x):
    return np.sin(x)/x

x = np.arange(-15.0, 15.0, 0.1)

plt.plot(x, f(x))
plt.show()
```

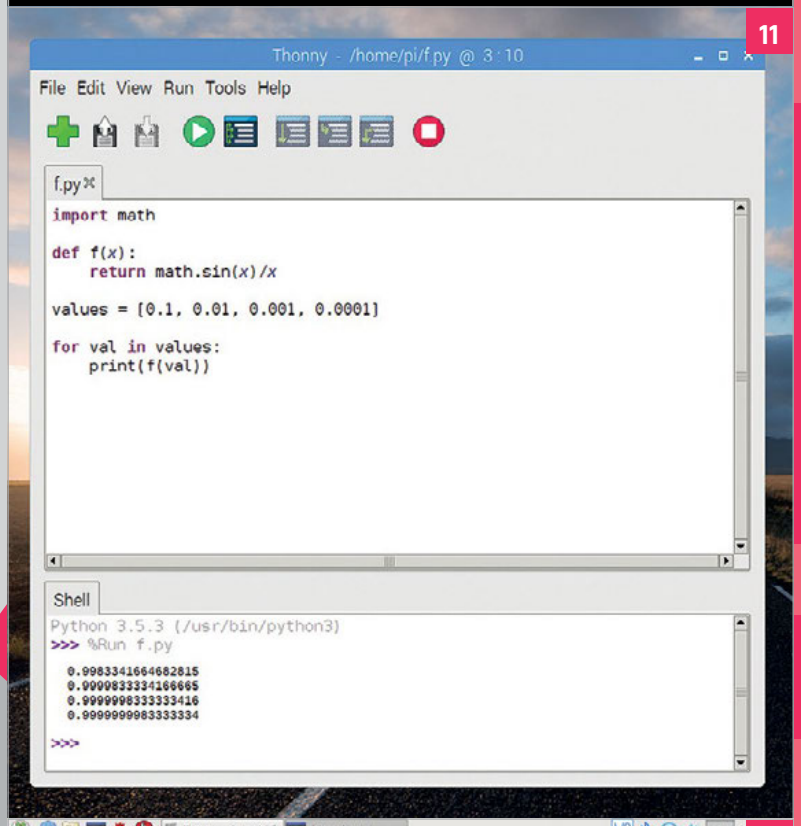
multiple_vs_exponent.py

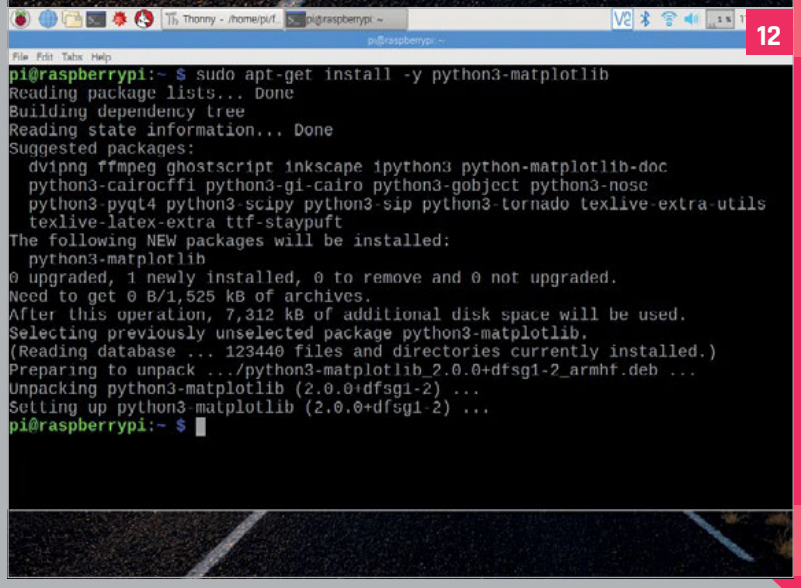
```
import matplotlib.pyplot as plt
import numpy as np

x = np.arange(-10, 10, 1)

plt.plot(x, x * 2, 'r^')
plt.plot(x, x ** 2, 'bo')

plt.show()
```

sine_cosine.py

```
import matplotlib.pyplot as plt
import numpy as np

def f(x):
    return np.sin(x)/x

def g(x):
    return np.cos(x)

x = np.arange(-15.0, 15.0, 0.1)

plt.plot(x, f(x), 'r', label="sin(x)/x")
plt.plot(x, g(x), 'b', label="cos(x)")

plt.legend()
plt.show()
```






12
pi@raspberrypi:~ $ sudo apt-get install -y python3-matplotlib
Reading package lists... Done
Building dependency tree
Reading state information... Done
Suggested packages:
dvipng ffmpeg ghostscript inkscape ipython3 python-matplotlib-doc
python3-cairocffi python3-gi-cairo python3-gobject python3-nose
python3-pyqt4 python3-scipy python3-sip python3-tornado texlive-extra-utils
texlive-latex-extra ttf-staypuft
The following NEW packages will be installed:
python3-matplotlib
0 upgraded, 1 newly installed, 0 to remove and 0 not upgraded.
Need to get 0 B/1,525 kB of archives.
After this operation, 7,312 kB of additional disk space will be used.
Selecting previously unselected package python3-matplotlib.
(Reading database ... 123440 files and directories currently installed.)
Preparing to unpack .../python3-matplotlib_2.0.0+dfsg1-2_armhf.deb ...
Unpacking python3-matplotlib (2.0.0+dfsg1-2) ...
Setting up python3-matplotlib (2.0.0+dfsg1-2) ...
pi@raspberrypi:~ $

>STEP-10

The math module

To expand Python beyond the basic arithmetic operators, you use the **math** module. This provides instant access to constants, like pi and e (the base of natural logarithms, approximately 2.718). It also offers a range of built-in functions such as sine, cosine, and absolute. See the 'Useful math functions' box on page 61 for some of the most common, or the Python Numeric and Mathematical Modules documentation for a full list (**magpi.cc/2xhtRsx**).

Gain access to all these using an **`import`** statement. Then use **`math`** and dot notation to access the function:

```
import math

math.sqrt(256) # returns 16.0
```

...and you'll get the square root of 256, which is 16 (it returns as a float so you actually get 16.0).

>STEP-11

Creating functions

Another fundamental aspect of Python is that you can create functions to perform conversions. Creating functions is a stock feature in all programming languages, but it really comes into its own when you're working with mathematical functions. Take our earlier function (from Calculator) where we tried to find the limit of sin(x)/x as x approaches 0. This function would typically be described as.

```
f(x) = sin(x)/x
```

We're going to open Thonny now (Programming > Thonny Python IDE). We can easily create a function in Python like this:

```
def f(x):

    return sin(x)/x
```

Then you can call the function with values, such as **`f(0.1)`** and **`f(0.01)`** to get the results. Or you could write a whole program to output a range. Enter the code from **f.py**.

>STEP-12

Matplotlib

Another advantage of working in Python is the ability to create graphs with two popular modules: NumPy and Matplotlib. NumPy is installed by default, but Matplotlib needs installing.

Make sure your Raspberry Pi is connected to the internet. Open Terminal and enter the following:

```
sudo apt-get install -y python3-matplotlib
```

ORDER OF OPERATIONS

Equations in Python work are calculated in strict order of operations, known as PEMDAS. Operators on the top of this list are calculated before ones on the bottom.

- `()` Parentheses
- `**` Exponentiation
- `*` Multiplication
- `/` Division
- `+` Addition
- `-` Subtraction

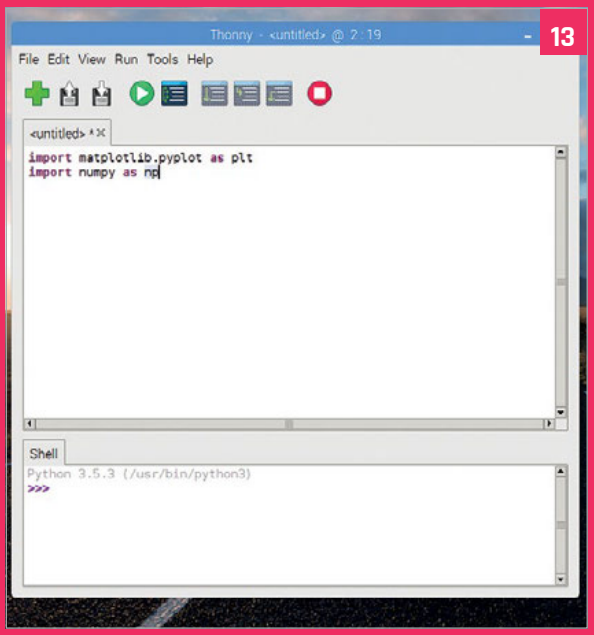
>STEP-13

Using plt and np

Return to Thonny and create a new file. Start with the following code:

```
import matplotlib.pyplot as plt

import numpy as np
```

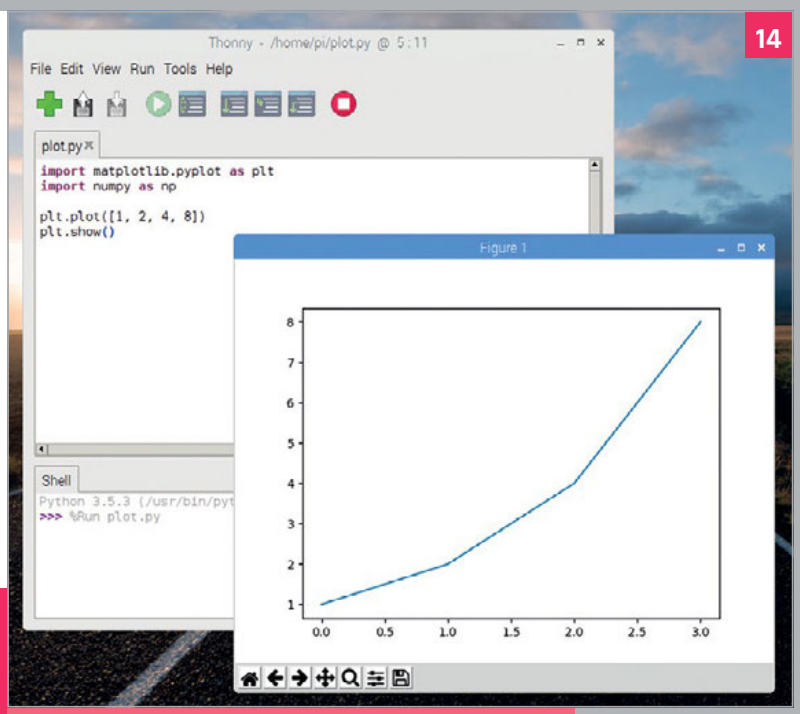
Both **np** and **plt** are fairly standard abbreviations, and you'll find them commonly used in Matplotlib tutorials, so it's best to use them consistently.



>STEP-14

Create a plot

Creating a plot with **plt** couldn't be easier. You pass a list of values to a **plot()** function, then use a **show()** function to open a window displaying them...



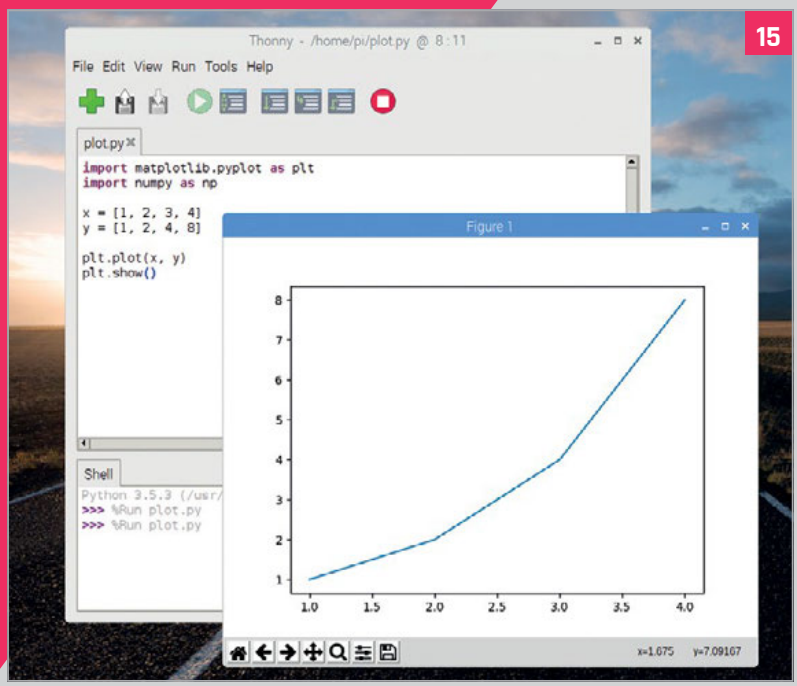

```
plt.plot([1, 2, 4, 8])

plt.show()
```

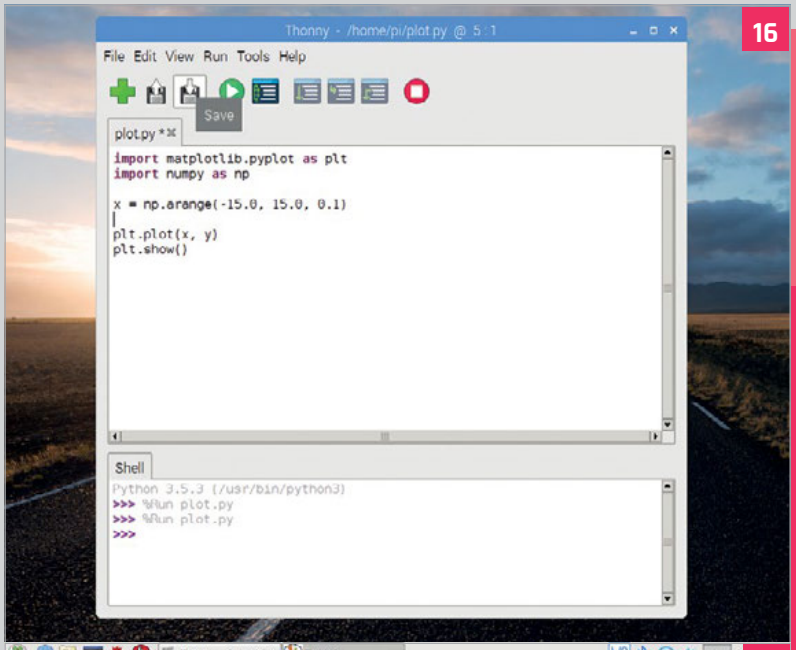
Look at the graph and you'll see that the first value (1) is at position 0 on the x line (the horizontal line). The 2 is at position 1, the 4 at position 3. These match the index number of the list. Click the X icon to close the window.

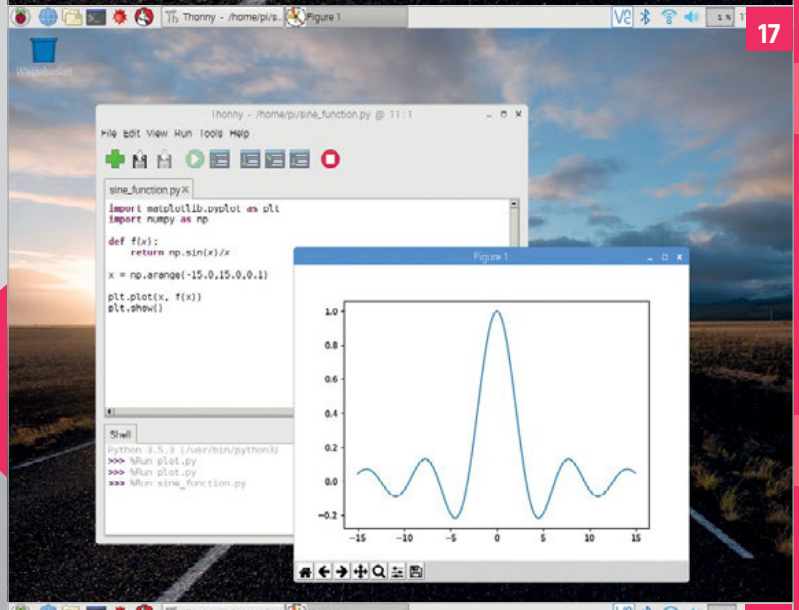
>STEP-15

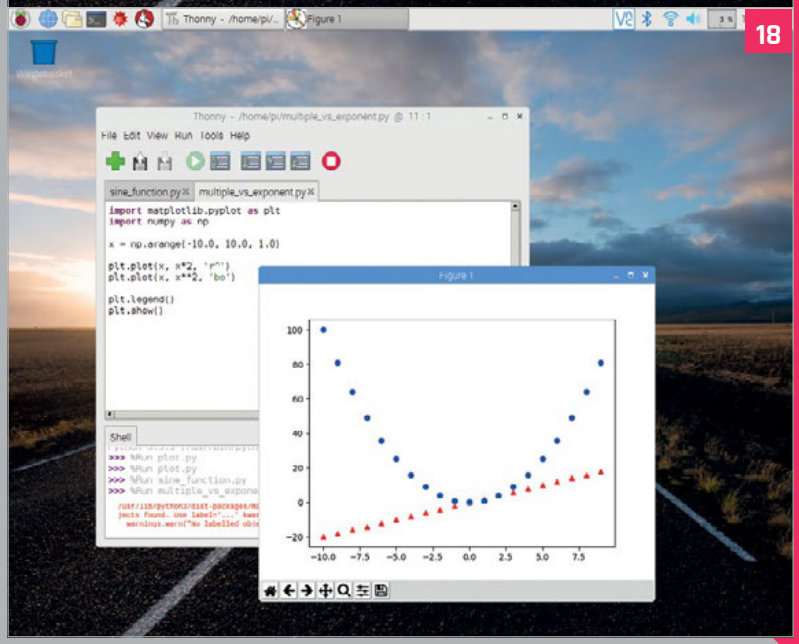
Set values manually

It is possible to set the x and y (horizontal and vertical) values manually.










```
x = [1, 2, 3, 4]

y = [1, 2, 4, 8]

plt.plot(x, y)

plt.show()
```

Now the x values (on the bottom of the graph) are numbered 1 to 4. They could be any numbers you like, such as 1, 4, 8, 12. But the amount of items in both the x and y lists must match when setting the values manually.

>STEP-16

Run a function

It's rare that you pass values manually to a plot. What's more likely is you'll use NumPy's **arange** function to create a range of numbers. The function looks like this:

```
x = np.arange(-15.0, 15.0, 0.1)
```

We pass three arguments into **np.arange()**. A start value, and end value, and a step. Our x-axis is going to run from -15 to 15 in increments of 0.1.

>STEP-17

Run the code

We then pass the x values to a function and plot the y values using our function, using this line of code:

```
plt.plot(x, f(x))
```

The full code for this can be seen in the listing **sine_function.py**. Notice that we've replaced **math.sin()** with **np.sin()**. It performs the same function. Run the code and you'll see a rather lovely sine wave in Terminal.

>STEP-18

Multiple plots

It's possible to chart more than one line in a Pyplot chart. Do this using more than one **plt.plot()** function. When using more than one plot, it's often handy to set different colours. You do this using a two-letter marker after the co-ordinate values.

The first letter is for the colour, and the second is for the style of line. So **ro** would indicate red circles, and **b^** indicates blue triangles. A complete list of markers can be found on the Matplotlib website (**magpi.cc/2hQBwvC**).

You can use a hyphen to indicate the default line, such as **g-** for a green line, or just use the letter on its own.

The code in **multiply_vs_exponent.py** demonstrates this.

>STEP-19

I am legend

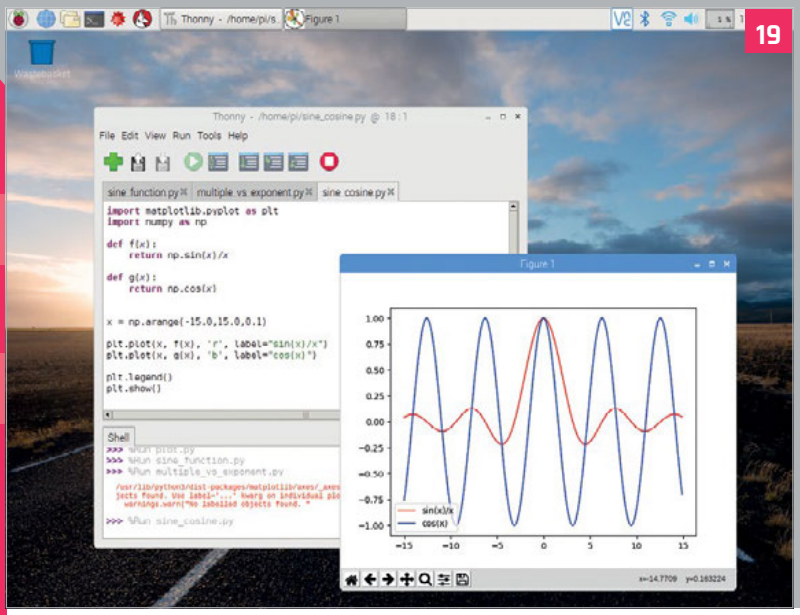
It's also a good idea to create a legend when putting together charts. Add the label tag to the **plt.plot()** function with some corresponding text, such as this:

```
plt.plot(x, np.cos(x), label="cos(x)")
```

Then use the **legend()** function to add the legend to the plot (before you use the **show()** function).

```
plt.legend()
```

In **sine_cosine.py** we have created a nice graph that compares sin(x)/x and cos(x). This code adds labels to the legend, and adjusts the colour of the lines.



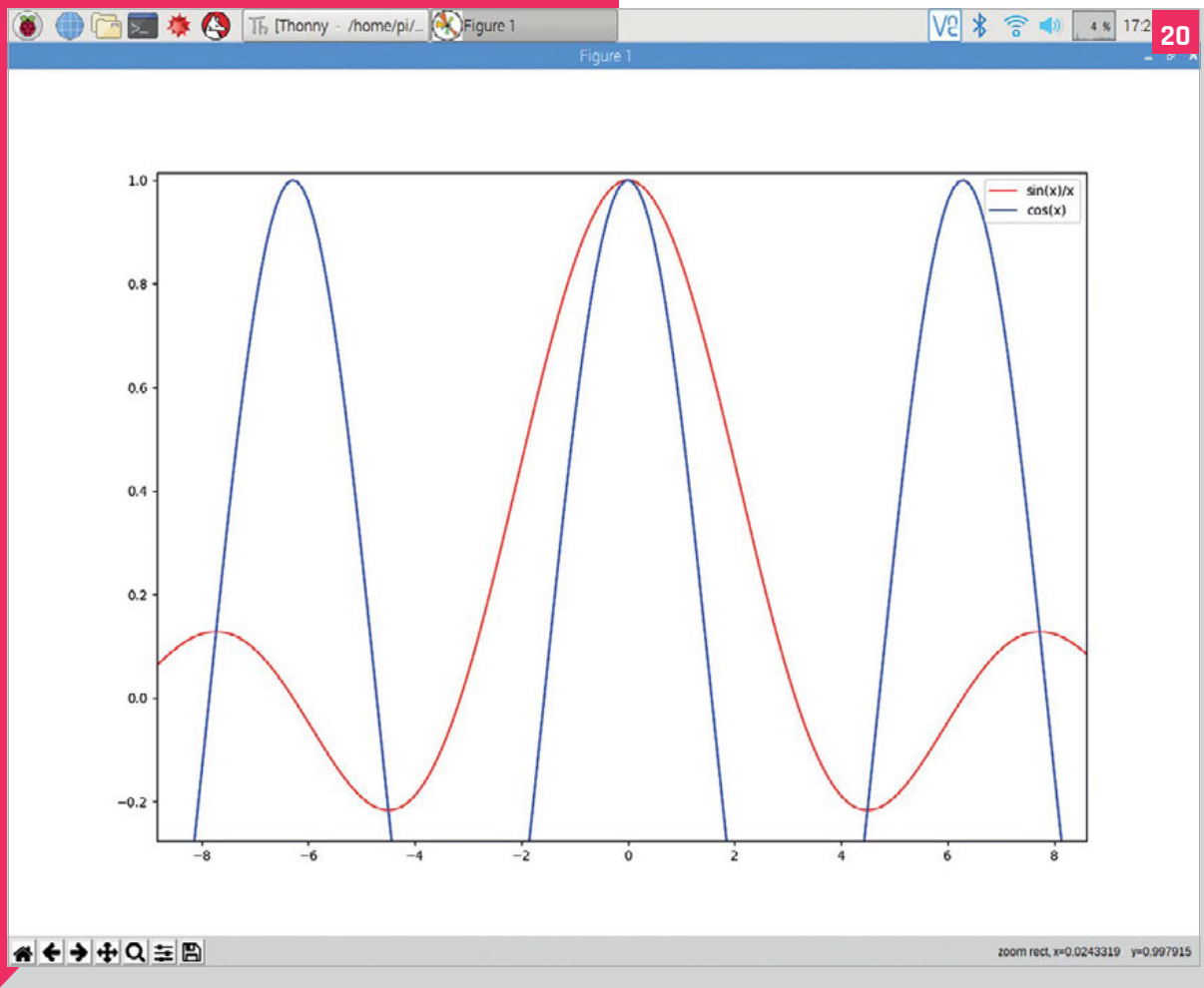
>STEP-20

Interact

You can interact with your graphs using the icons on the bottom. Use the Zoom icon and draw a marquee around an area of the plot to zoom in on it. Then use the Back and Forward icons to move between the full view and the zoomed one. Hover the mouse over areas of the graph to view the co-ordinate values at that point. Finally, you can save the figure as a PNG using the 'Save As' icon.

USEFUL MATH FUNCTIONS

- **abs()** for absolute value
- **divmod()** to find a quotient and remainder simultaneously
- **pow()** to raise a number to a certain power
- **round()** to round a number to a certain decimal point
- **sum()** to calculate the sum of the items in an iterable data type



FREQUENTLY ASKED QUESTIONS

NEED A PROBLEM SOLVED?

Email **magpi@raspberrypi.org** or find us on **raspberrypi.org/forums** to feature in a future issue.

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USING RASPBERRY PI FOR HOME AUTOMATION

WHAT IS HOME AUTOMATION?

An automatic home

Imagine if your house reacted to you and your life. Turning lights on as you walk into the room. Drawing the curtains when it gets dark. Setting the house alarm when you leave. Simple things that a computer can handle with the right timing and triggers.

The benefits

As well as being a cool party piece and making you feel like you live on the USS Enterprise, it's useful for people with disabilities. In the latter case it's known as assistive domotics and is focused more on safety; however, this does create crossover in functionality.

Better control

With the advent of more powerful voice assistants, home automation also allows for easier control of your house. Using voice commands to play music or turn on your TV is very Star Trek and thanks to Google Home and Amazon Echo devices, it's very easy to set up now.

HOW DOES THE RASPBERRY PI WORK IN HOME AUTOMATION?

Control unit

The Raspberry Pi won't be able to directly interact with all your appliances and such in the same way you can control LEDs with GPIO Zero in Python, but you'll be able to connect it to specially made connected products like wireless light bulbs and plug adapters. Using home automation software, you can then arrange for the Pi to control them all.

Control software

Control software such as openHAB (**openHAB.org**) runs off the Raspberry Pi and is accessible via a browser. You then program the behaviour of individual devices from the web interface, allowing you to modify and optimise from wherever you have access to a network.

Home automation devices

Products that are designed for home automation generally run on certain standards which easily connect to the Pi, such as the Phillips Hue range of lights. These can be controlled on their own or hooked up to your Pi using automation software.

WHAT RESOURCES ARE THERE FOR RASPBERRY PI HOME AUTOMATION?

Documentation and instructions

Software like openHAB has plenty of documentation on how to connect up devices with itself. Many home automation products come with relevant instructions as well, so you'll be able to follow along to them to get started.

Project guides

You'll find plenty of inspiration and even step-by-step guides from other makers online, such as this one on Instructables: **magpi.cc/2yJXRTf**. There are lots of others as well – from some using hands-free automation, all the way down to using control panels in your house to interact with everything.

Community

As always, the Raspberry Pi forums are a great place to go if you want to get some help with something specific. Use the search function to see if your issue has been covered before, but otherwise you can ask a question and usually get a great answer: **raspberrypi.org/forums**.

FROM THE RASPBERRY PI FAQ
RASPBERRYPI.ORG/HELP

WHAT DO I GET WHEN I BUY ONE?

You get the Raspberry Pi board itself. A power supply and SD card are not included, but can be purchased at the same time from most places that sell the Raspberry Pi. You can also purchase preloaded microSD cards; we recommend buying these from us or our licensed distributors rather than from third parties on eBay, as our software is updated regularly and cards sold by third parties can quickly become outdated.

WHY IS THE PRICE IN US DOLLARS? YOU ARE A UK COMPANY!

The components we buy are priced in dollars, and we negotiate manufacturing in dollars. Because currency markets are so volatile, we price the final board in dollars as well so we don't have to keep changing the price.

CAN I BUY A RASPBERRY PI KIT?

Raspberry Pi resellers produce some fantastic bundles for people who would rather get everything they need from a single source. In 2016, we put together our own Raspberry Pi Official Starter Kit. The kit is available to order online in the UK from our partners element14 (**magpi.cc/2cCT8pk**) and RS Components (**magpi.cc/2nrY33i**), priced at £99+VAT, and from distributors and resellers around the world.

IS THERE A BUY-ONE-GIVE-ONE PROGRAMME?

Not at the current time. We may implement a programme of this sort one day, but the scale of an undertaking like this is something our small team isn't equipped to handle. You can, of course, simply buy an extra Raspberry Pi to donate to the person or organisation of your choice.

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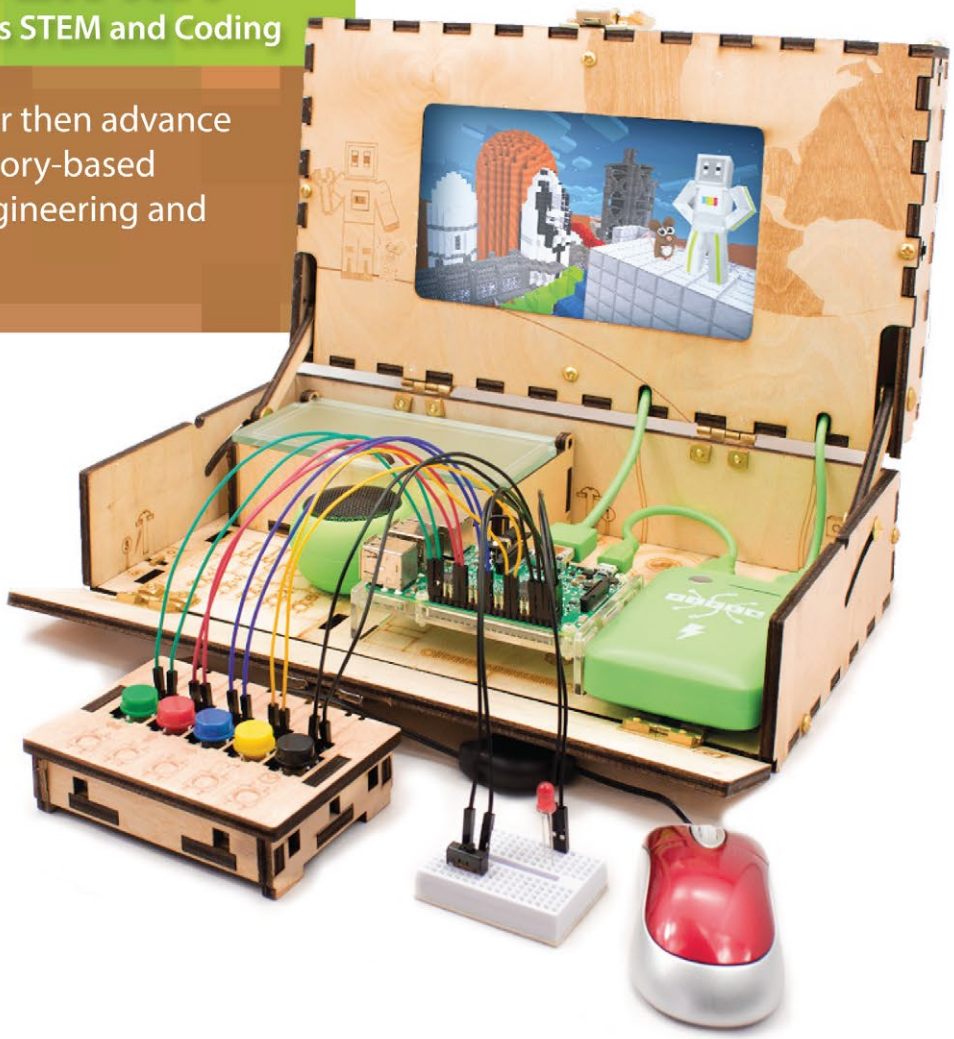

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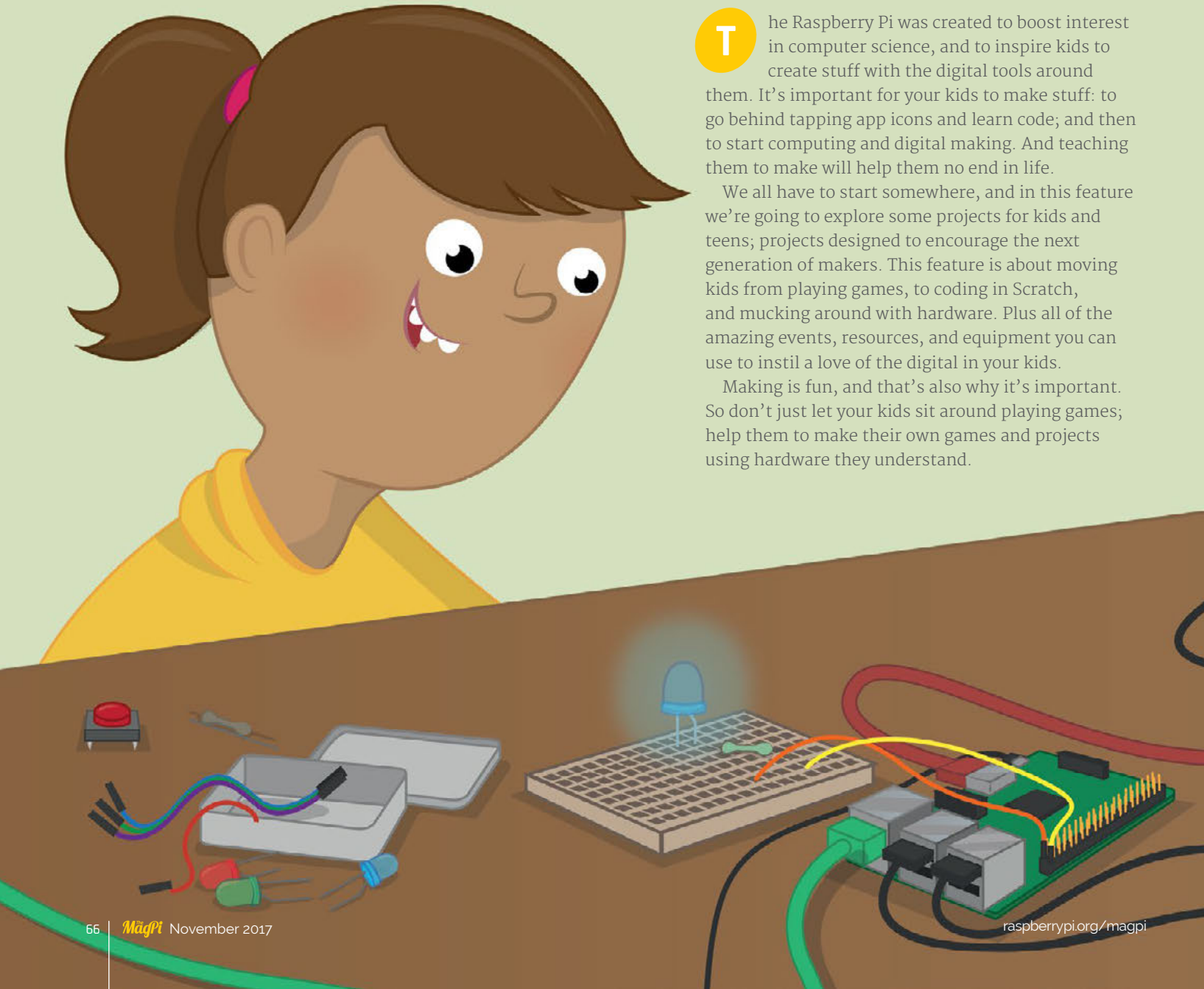
JUNIOR PI PROJECTS

Raspberry Pi projects that inspire kids, teens, and young adults to become digital makers



The Raspberry Pi was created to boost interest in computer science, and to inspire kids to create stuff with the digital tools around them. It's important for your kids to make stuff: to go behind tapping app icons and learn code; and then to start computing and digital making. And teaching them to make will help them no end in life.

We all have to start somewhere, and in this feature we're going to explore some projects for kids and teens; projects designed to encourage the next generation of makers. This feature is about moving kids from playing games, to coding in Scratch, and mucking around with hardware. Plus all of the amazing events, resources, and equipment you can use to instil a love of the digital in your kids.

Making is fun, and that's also why it's important. So don't just let your kids sit around playing games; help them to make their own games and projects using hardware they understand.

FLAPPY PARROT

Make a version of this mobile arcade favourite

68

70

SLUG! SNAKE ON SENSE HAT

Create the classic game, Snake, using the LED lights on a Sense HAT

72

BUILD A ROBOT BUGGY

Take your making to the next level with a code-controlled robot

MAKING MATTERS

Digital making inspires young people to learn hands-on learning and tinkering skills. As makers and hackers, we naturally think this is a good thing, but it's not just about feeling good. Kids who learn to tinker around with stuff get a deeper understanding of how something works. Makers have a deeper understanding of what objects in the modern world are, and their purpose and limitations. We think it's vital that kids grow up to make stuff, and not just consume it.

FLAPPY PARROT

Make your own frenetic arcade game

YOU'LL NEED

- Raspberry Pi
- Raspbian
- Scratch 2.0

LANGUAGE
>SCRATCH

FILE:
FlappyParrot.sb2

DOWNLOAD:
magpi.cc/2gbaNJO

You may bristle at the thought of your kids wasting time on video games, but it turns out they are a great way to sneakily introduce kids to coding techniques. It's known as 'stealth education', and Raspberry Pi comes with the greatest stealth education kit of all built in: Scratch.

With Scratch, kids can develop their own video games and interactive animations.

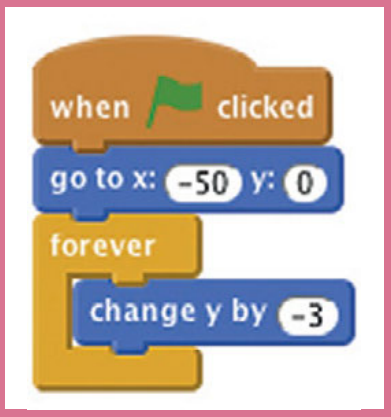
In this project, we'll make our own version of the highly popular mobile game Flappy Bird. The project requires Scratch 2.0, which is in the latest version of Raspbian.

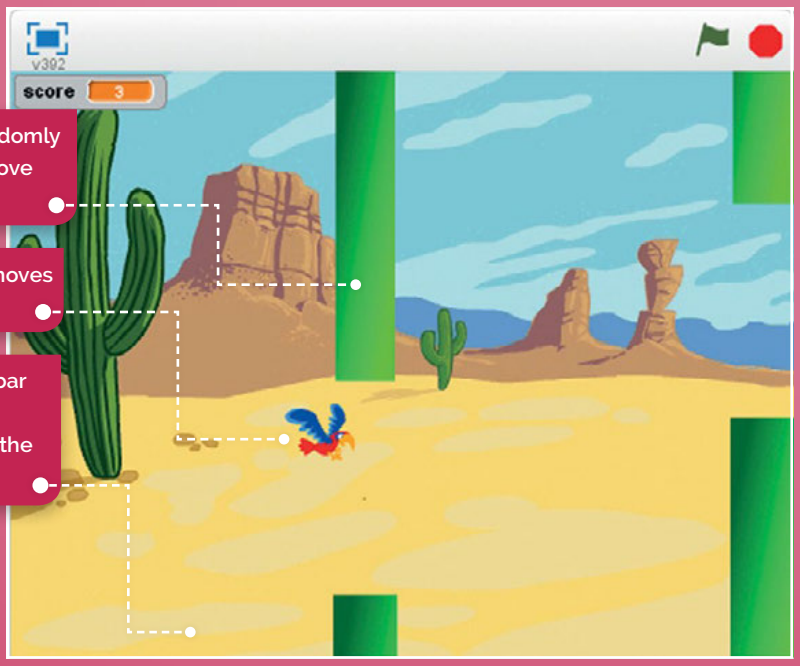
Flappy Bird was a huge hit; it's also a very simple game to program, with just up and down movement of the bird and a single button interaction. Our program here uses a keyboard input, but you could easily use Scratch 2.0 with the GPIO pins to hook the game up to a physical button.

>STEP-01
Meet Flappy

From the Raspbian Menu, select Programming > Scratch 2 and start a new Scratch project. Delete the cat by right-clicking it and selecting Delete. Click the 'Choose backdrop from library' icon and select desert. Click OK. Now click 'Choose sprite from library', select Parrot, and click OK. Right-click on the Parrot sprite and choose Info. Change the name of your sprite to Flappy. Click on Shrink and click on the Parrot 15 times to shrink it down to size.

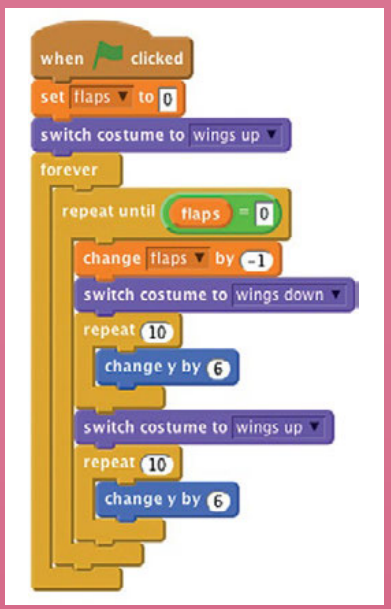
Now give little Flappy the following script:




v392
score 3
The pipes are randomly generated and move from right to left
The Flappy Bird moves up and down
Press the SPACE bar to flap and try to navigate through the gaps in the pipes

>STEP-02
Make Flappy fly

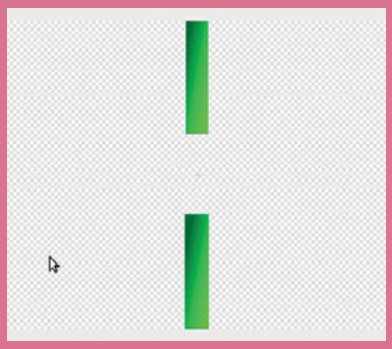
Next, we want Flappy to flap upwards when you press the **SPACE** bar. Flappy must respond every time we press **SPACE**; we also use a variable, **flaps**, to count the times it has been pressed, so Flappy will respond to further presses during the animation loop. Add the following two scripts:



>STEP-03
Add the pipes

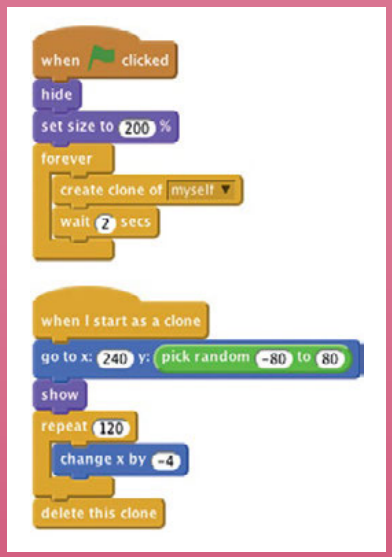
Now, we'll add some obstacles for Flappy to fly through. First, click on the 'Paint new sprite' button and name the costume 'pipe'. Click on the 'Convert to vector' button. Click Rectangle and click on the 'Filled rectangle' button. Click and drag two boxes, one from the top middle and one from the bottom middle, as shown below.

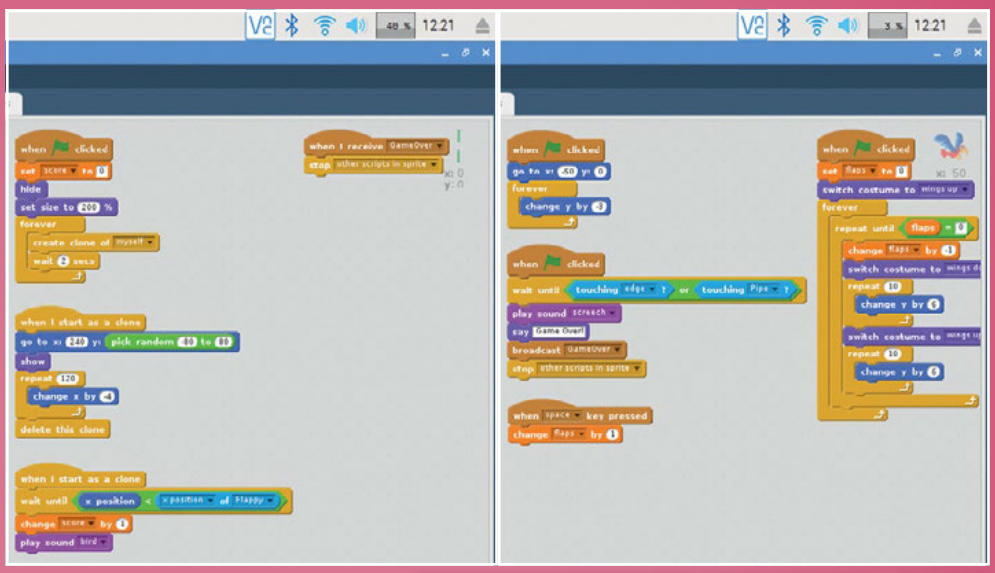
You can shade your pipes by clicking on the 'Color a shape' button and click on the 'Horizontal gradient' button. Choose two shades of the same colour, one for the foreground and one for the background. When you click to fill the shapes, the colours will fade between your chosen shades. Rename the sprite Pipe.



>STEP-04
Make the pipes move

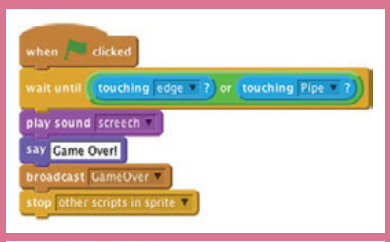
Next we'll use some blocks to make the pipes move and arrange them randomly to provide an obstacle course for Flappy.





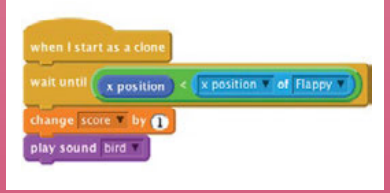
>STEP-05
Detect collision with the pipes

To make the game a challenge, the player needs to guide Flappy through the gaps without touching the pipes or the edges of the screen. Now we'll add some blocks to detect if Flappy hits something. Click on the Pipe sprite and add these scripts:


when clicked
wait until touching edge ? or touching Pipe ?
play sound screech
say Game Over!
broadcast GameOver
stop other scripts in sprite

>STEP-06
Add scoring

Finally, the player should score a point every time Flappy makes it through a pipe. Let's add that next. Check your code for both the Flappy sprite and Pipe sprite against the full code listing (top of page). Click the green flag to play a game of Flappy Parrot. Good luck!

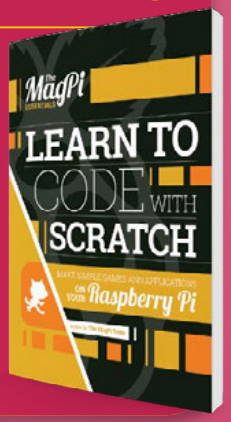


JOIN A CLUB

Getting your kids into a coding club is the best way to spark a love of hacking and making with code. Code Club UK is a nationwide network of volunteers and educators who run free coding clubs for young people aged 9–13 (**codeclub.org.uk**). If you're outside the UK, take a look at **codeclubworld.org**. CoderDojo (**coderdojo.com**) is also a network of free, volunteer-led, community-based programming clubs for young people aged 7 to 17.

SCRATCH ESSENTIALS

Created by the boffins at MIT, Scratch enables children and adults without any prior knowledge to start programming within minutes. In the *Scratch Essentials* book, we help you get started and guide you step-by-step through the process of creating all sorts of projects: games, animations, quizzes, electronics circuits, and more.



SLUG! SNAKE ON SENSE HAT

Create the classic game, Snake, using the LED lights on a Sense HAT

YOU'LL NEED

- Raspberry Pi
- A Sense HAT magpi.cc/1TGGUt5
- Sense HAT emulator

Now that you've got your kids creating games in Scratch, it's time to introduce them to Python. There are lots of games recreated in Python, and we have a whole book called *Make Games with Python* (**magpi.cc/2h2movh**) which you can download for free.

This code hooks up Python to the amazing Sense HAT hardware to create a fun and frantic version of the classic game Snake. Guide the slug around the screen to let her eat vegetables, watch her grow, and increase your score. Don't let her bite into herself, though, or it's game over!

>STEP-01
Sense HAT or simulation

Attach the Sense HAT to your Raspberry Pi and connect it to a television and keyboard as normal. You will program the Raspberry Pi directly using the keyboard and screen, but then play the game using the Sense HAT joystick and LED display. If you don't have a Sense HAT, don't worry: you can still play the game using the Sense HAT Emulator built into Raspbian.

>STEP-02
Enter the code

Open Thonny (Menu > Programming > Thonny Python IDE) and choose File > Save. Enter **slug.py** as the File name and click Save. Now carefully enter the code from **slug.py** into the editor window.

>STEP-03
Test the code

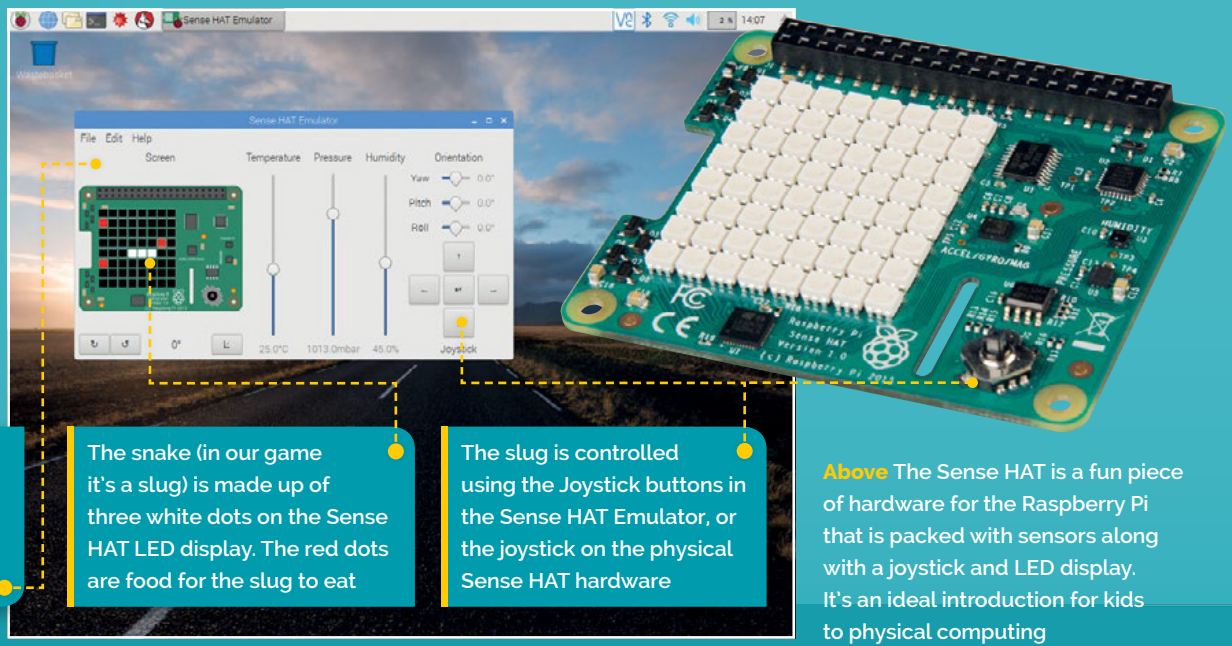
Click the green Run button to test out the code. The Sense HAT emulator should open with the slug moving from left to right. Use the buttons to control the code. Close the emulator window and click the red Interrupt button to stop the program running.

>STEP-04
Run the code

Now, in the first line, change `sense_emu` to `sense_hat`. It should read like this:

```
from sense_hat import SenseHat
```

Click Run again and the slug game will run on the Sense HAT itself. You can now control the game using the joystick on the Sense HAT.


Sense HAT Emulator
File Edit Help
Screen
Temperature
Pressure
Humidity
Orientation
Yaw
Pitch
Roll
Joystick
The Sense HAT Emulator lets you test out the program on your Raspberry Pi
The snake (in our game it's a slug) is made up of three white dots on the Sense HAT LED display. The red dots are food for the slug to eat
The slug is controlled using the Joystick buttons in the Sense HAT Emulator, or the joystick on the physical Sense HAT hardware

Above The Sense HAT is a fun piece of hardware for the Raspberry Pi that is packed with sensors along with a joystick and LED display. It's an ideal introduction for kids to physical computing

LANGUAGE
>PYTHON

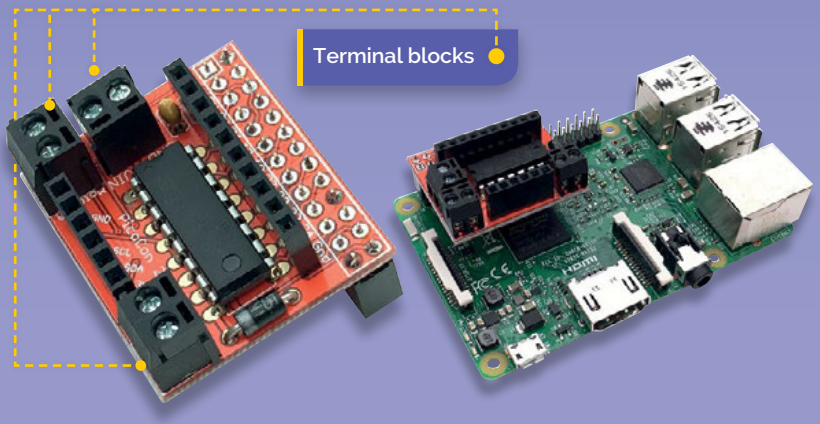
FILE:
slug.py

DOWNLOAD:
magpi.cc/2zguynp

slug.py

```
001. from sense_hat import SenseHat
002. from time import sleep
003. from random import randint
004.
005. sense = SenseHat()
006.
007. # Variables ---------------------------
008. slug = [[2,4], [3,4], [4,4]]
009. white = (255, 255, 255)
010. blank = (0, 0, 0)
011. red = (255, 0, 0)
012. direction = "right"
013. vegetables = []
014. score = 0
015. pause = 0.5
016. dead = False
017.
018. # Functions ---------------------------
019. def draw_slug():
020.   for segment in slug:
021.     sense.set_pixel(segment[0], segment[1], white)
022.
023. def move():
024.   global score, pause, dead
025.   remove = True
026.
027.   # Find the last and first items in the slug list
028.   last = slug[-1]
029.   first = slug[0]
030.   next = list(last) # Create a copy of the last item
031.
032.   # Find the next pixel in the direction the slug is
      currently moving
033.   if direction == "right":
034.
035.     # Move along the column
036.     if last[0] + 1 == 8:
037.       next[0] = 0
038.     else:
039.       next[0] = last[0] + 1
040.
041.   elif direction == "left":
042.
043.     if last[0] - 1 == -1:
044.       next[0] = 7
045.     else:
046.       next[0] = last[0] - 1
047.
048.   elif direction == "down":
049.
050.     if last[1] + 1 == 8:
051.       next[1] = 0
052.     else:
053.       next[1] = last[1] + 1
054.
055.   elif direction == "up":
056.
057.     if last[1] - 1 == -1:
058.       next[1] = 7
059.     else:
060.       next[1] = last[1] - 1
061.
062.   # Did I die?
063.   if next in slug:
064.     dead = True
065.
066.   # Add this pixel at the
      end of the slug list
067.   slug.append(next)
068.
069.   # Set the new pixel to the slug's colour
070.   sense.set_pixel(next[0], next[1], white)
071.
072.   if next in vegetables:
073.     vegetables.remove(next)
074.     score += 1
075.
076.     if score % 5 == 0:
077.       remove = False
078.       pause = pause * 0.8
079.
080.   if remove == True:
081.     # Set the first pixel in the slug list to blank
082.     sense.set_pixel(first[0], first[1], blank)
083.
084.     # Remove the first pixel from the list
085.     slug.remove(first)
086.
087.
088. def joystick_moved(event):
089.   global direction
090.   direction = event.direction
091.
092. def make_veg():
093.   new = slug[0]
094.   while new in slug:
095.     x = randint(0, 7)
096.     y = randint(0, 7)
097.     new = [x, y]
098.   sense.set_pixel(x, y, red)
099.   vegetables.append(new)
100.
101. # Main program ------------------------
102. sense.clear()
103. draw_slug()
104.
105. sense.stick.direction_any = joystick_moved
106.
107. while not dead:
108.   move()
109.   sleep(pause)
110.
111.   # Have a 20% chance of making a veggie if there
      aren't many about
112.   if len(vegetables) < 3 and randint(1, 5) > 4:
113.     make_veg()
114.
115. sense.show_message( str(score) )
```

BUILD A ROBOT BUGGY



Take your making to the next level with a code-controlled robot

YOU'LL NEED

- Raspberry Pi
- Motor controller board
- 2 × DC motors
- A 6V AA battery pack
- 2 × Wheels
- Ball caster (or suitable alternative)
- Plastic container
- Blu Tack or similar

Once you've made games with your kids, it's a great idea to move them to a pure hardware project. One of the best around is a robot kit. You can build a robot buggy that you can program to move around using simple Python commands.

The components in this project are all included in the CamJam EduKit 3, which you can purchase from The Pi Hut for just £18 (**magpi.cc/2yfsXAN**). Or you can pick up all the parts separately.

>STEP-01

Set up the motor control unit

Take your motor controller board and, using a small screwdriver, loosen the screws in each of the three terminal blocks. The battery pack must be connected so that the red wire goes into port labelled VIN. The black wire goes into the port labelled GND. Make sure the battery pack is turned off when you do this. The motors can be connected to their terminal blocks any way around. Then tighten the screws again.

>STEP-02

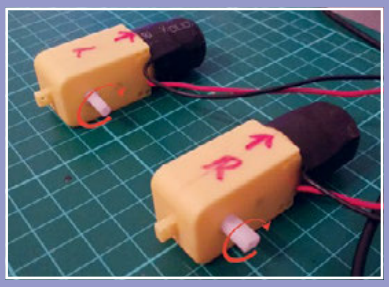
Attach the motor control unit

The kind of motor controller board used in this project can sit directly on the Raspberry Pi GPIO header pins, and uses GPIO 7, 8, 9, and 10. With the motors and battery connected and the Pi switched off, you can place the board over the GPIO pins as shown above.

>STEP-03

Test the motors

Once you have assembled the hardware and your Raspberry Pi is



powered up, you can test that the motors are both working.

With your motor controller board and motors wired up, you can use a little bit of Python to control the motors. Open Thonny by clicking on Menu > Programming > Thonny Python IDE. Save your file as **motor_test.py** and add the following code:

```
from gpiozero import Motor
motor_1 = Motor(7, 8)
```

Now you can use the following commands to drive your motors:

robot.py

LANGUAGE
>PYTHON

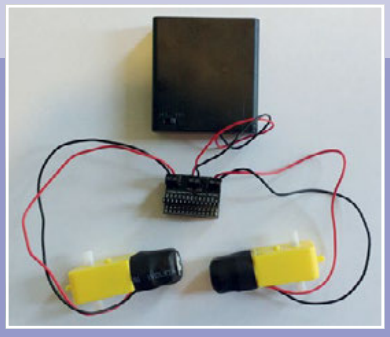
FILE:
robot.py

DOWNLOAD:
magpi.cc/2zviWPw

```
from gpiozero import Robot
robot = Robot(left = (7, 8), right = (9, 10))
while True:
        robot.forward()
        sleep(3)
        robot.stop()
        robot.right()
        sleep(1)
        robot.stop()
```

```
motor_1.forward()
motor_1.backward()
motor_1.stop()
```

If you want to control both motors simultaneously, you can use the **Robot** class, as we will do here.



>STEP-04
Test the robot

It is important to know which is your left motor and which is your right motor. You also need to know which way they are driving to go forward, and which way they are driving to go backwards.

Choose either of the motors. Use a marker pen to label it 'right' and draw an arrow on it to indicate which way is forward. Label the other motor 'left' and draw an arrow on it pointing in the same direction as your first one.

>STEP-05
Motor control

Enter and run the code from **robot.py**. If one of the motors runs backwards, you'll need to swap around the black and yellow wires for that robot on the motor control unit (switch everything off first).

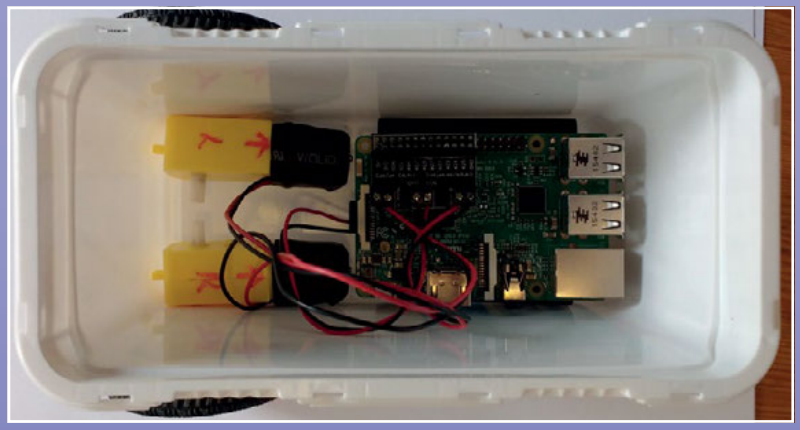
If your left and right are mixed up you can swap wires on the motor control unit or change GPIO values in the **robot** variable:

```
robot = Robot(right = (7,
8), left = (9, 10))
```

>STEP-06
Assemble the robot

There is no right way to build your robot chassis. The motors are held in place with a little Blu Tack. With the wheels in place, a ball caster can be screwed to the container to act as a third wheel.

You can power your Raspberry Pi using a power brick. At this stage, you're probably going to want to connect to the Raspberry Pi remotely. You can do this via SSH or VNC (see Remote-control your Raspberry Pi, **magpi.cc/2iqniNO**).



THREE ROBOTS

MEARM PI

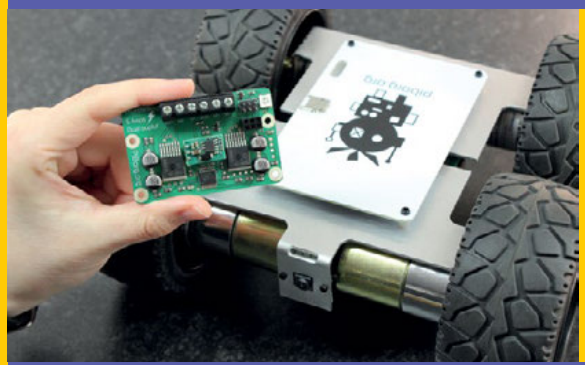
magpi.cc/2y7E5xq

This robot arm includes a HAT with twin on-board joysticks, so you have everything you need in one kit. Manual control using the joysticks is great fun, but programming it is ultimately more rewarding.

GOPIGO 3

magpi.cc/2vsYrzQ

GoPiGo is one of the most impressive robot kits available for the Raspberry Pi, and especially useful for teachers. The two motors have encoders built in, measuring the precise rotation of the wheels.



MONSTERBORG

piborg.org/monsterborg

This heavy-duty racing robot stars in Formula Pi, a series of robotic racing events around the UK. It can be set up as an RC racer thanks to its chunky wheels and four 300 rpm motors. But kids also learn programming skills with the robot following coloured lines on racetracks.

Maker Says

"A beast of a kit designed to be taken off road or driven autonomously"

PiBorg

MONSTERBORG

Off-road robot stomps onto Raspberry Pi in style. **Lucy Hattersley** reviews the rough, gruff, and tough MonsterBorg

We see many robots here at MagPi Towers: some are highly educational, others are fun hackable toys; a few have industrial aspirations; but the MonsterBorg is in its own league.

With its massive 105mm wheels, sturdy 3mm aluminium chassis, and four stonkingly powerful 300rpm motors, it's a beast.

The MonsterBorg mocks educational robots, smirks at toy rovers and tears off around the off-road track. As you might have guessed, we had a lot of fun testing out the MonsterBorg.

You can control it with a wireless gamepad, use a web interface (along with an optional Camera Module for a spy-cam), or you can program MonsterBorg to run autonomously.

At its heart is the equally extreme-sounding ThunderBorg motor controller. This is a powerful new 5amp dual motor controller for the Raspberry Pi. It runs between 7V and 35V, and more boards can be plugged in to handle up to 200 motors if you want to go all 'Jeremy Clarkson' on your robots.

The MonsterBorg kit hooks a single ThunderBorg up to four 300rpm Zhengke 37mm motors (pre-soldered), one for each of the chunky wheels.

It needs ten AA batteries for three hours of runtime and you can run it around the garden, on the track, or around the park. All of this is held together on a 3mm thick aluminium chassis that sits in the middle of the wide tyres (so it can keep rolling if flipped over).

The build quality of the MonsterBorg mightily impressed us. Every part fits together neatly and precisely, and the components are all high quality. It feels capable of taking a few hard knocks.

You need to bring your own Raspberry Pi to the party. It supports Pi 3, Pi 2, B+ or Pi Zero W devices,

Related

GOPIGO3 STARTER KIT

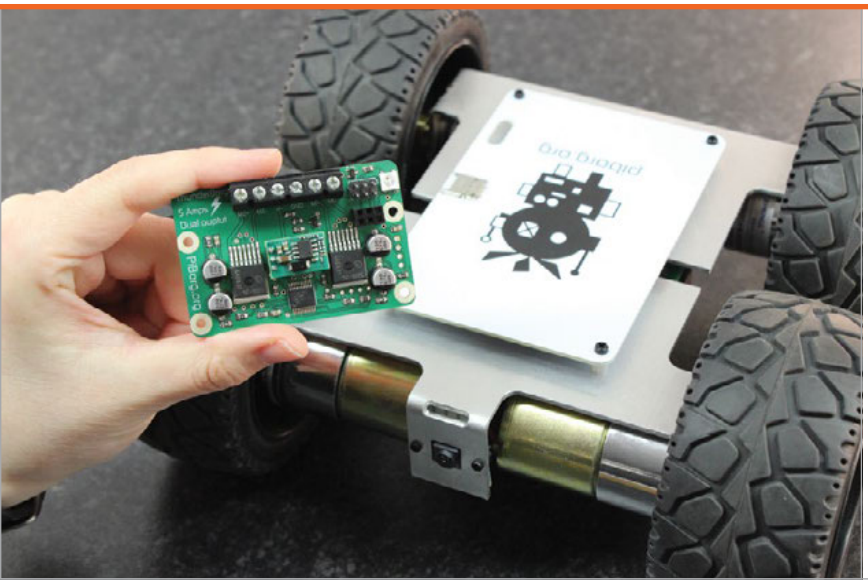
The refined, precise, and thoughtful GoPiGo3 is almost the polar opposite of the MonsterBorg. It's a completely different experience for around the same price.

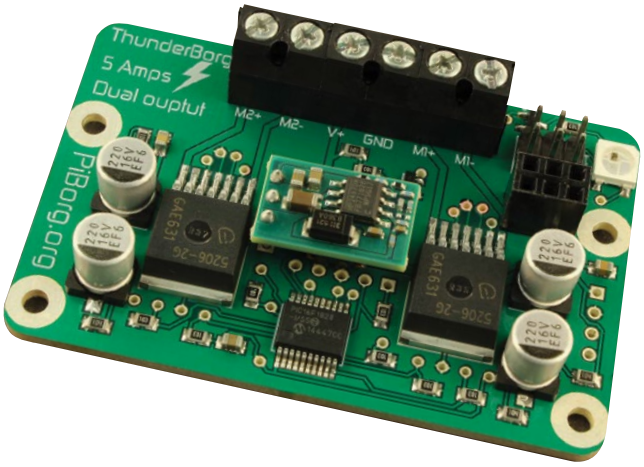
£199 / $199

magpi.cc/2vsYrzQ

piborg.org

£200 / $261





although we think it's best to use a Pi 3 or Pi Zero W as they have built-in wireless networking (there's not much space for dongles). You also need to add your own microSD card and an optional (but highly recommended) Pi Camera Module, which makes the web UI option possible… All of which does push the price up a bit if you don't have plenty of spares.

Putting together the MonsterBorg took around an hour and, thanks to its chunky wheels, sturdy frame, and whopper motors, it's a fun build.

We found the nest of wires the only real sticking point: it took us a while to get them all tucked inside the kit. It's also nigh-on impossible to reach the USB sockets or microSD card once you've set up the robot.

So make sure you set up the Raspberry Pi for SSH or VNC before assembling the kit. It's also a good idea to fix the Raspberry Pi IP address on your router so it doesn't lose track of it.

PiBorg has created software installation instructions (**magpi.cc/2xtYMlh**) and a photo build guide (**magpi.cc/2xu9fNI**). We found the whole build process simple and straightforward.

With the software installed, you can control MonsterBorg by joystick, via a web interface, or create a canned sequence.

> "You can control MonsterBorg by joystick, via a web interface, or create a canned sequence"

Perhaps more interesting is the Self Drive mode where the MonsterBorg follows a single coloured track. This is the technique used in Formula Pi events (**formulapi.com**), and the MonsterBorg is now the Formula Pi standard robot.

This integration with Formula Pi shouldn't be underestimated. Far too often when you build a robot, the question is 'what to do with it?'. With MonsterBorg you have an answer: set it up for racing meets.

It lacks all the finesse and precision of another robot we love, the GoPiGo3, with its built-in encoders. Mind you: the MonsterBorg has got its 300rpm motors and they put a wide smile on our face. So it's six of one and half a dozen of the other.

MonsterBorg is one of the few Raspberry Pi robots that encourages you to take it outside and play. This, along with the Pi Camera Module and web-based UI functionality, makes for a go-getting outdoor rover. An approach that we feel could be far more interesting to budding roboticists than the school lab environment that many other robots find themselves trapped in.

MonsterBorg is an utterly unpretentious robot that's unrepentantly good fun. Don't be fooled by its rough and ready approach: this is a well-engineered piece of kit with some clever software and a good team behind it.

Last word

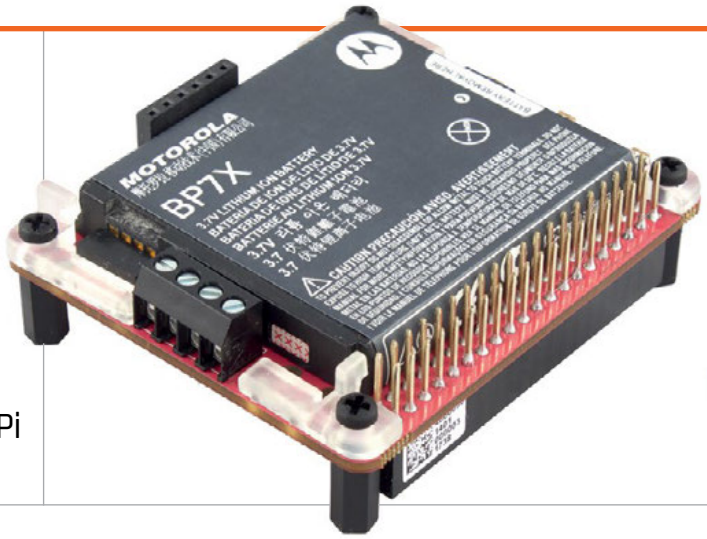
It's rough and tumble but it's fun to assemble, easy to get running and packs a lot of power. We loved the MonsterBorg and could happily spend all day playing with it. It's equally at home on the race track and in the park, and is the perfect blend of RC-style racing with robotic intelligence.

★★★★★

Maker Says

"A portable project platform for every Raspberry Pi"

PiSupply



PIJUICE

Use your Pi anywhere with this smart portable power solution

You may recall the PiJuice Kickstarter campaign if you have a good memory – it was back in March 2015 and proved extremely popular, achieving a funding level of over 1200%. So, why the long delay to get it into production? Well, it seems it was due to a combination of technical, manufacturing, and business issues, but here it is at last, so let's find out if it has been worth the wait.

The PiJuice comes preloaded with a Motorola BP7X 1820mAh phone battery, which can easily be lifted out and replaced with an alternative if needed. The board has a pre-soldered header so it fits snugly onto the Raspberry Pi's GPIO pins, but extends them to its own full set of GPIO pins above, so you can still plug in another HAT or add-on – the PiJuice only uses I²C pins. Four stand-offs keep it sturdy atop the Pi. It's a much neater solution than most portable power methods – no messy wiring here.

Not only is it neater, but it's far smarter, thanks to its STM32-F0 microcontroller chip, real-time clock, and Pi software. It can therefore offer a range of advanced power management features – akin to those of the Witty Pi 2 – that make it more useful than simply plugging your Pi into a USB power bank. It can also be used to provide an uniterruptable power supply.

After downloading the software (with `sudo apt-get pijuice`), a battery status icon then appears in the task bar of the Raspbian desktop; hover over it to see the current charge percentage, or right-click to access a plethora of configuration settings.

Related

LIPO SHIM

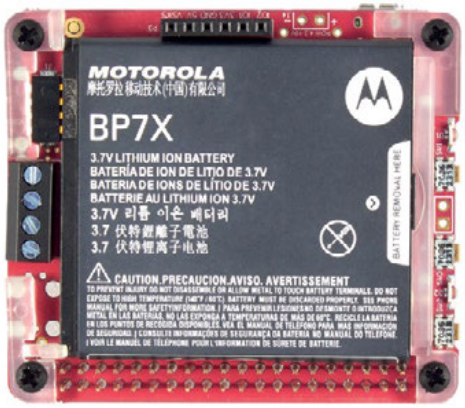
Formerly known as the Zero LiPo, this little shim can be soldered to the Pi's GPIO pins and hooked up to a LiPO battery back and charger (not supplied).

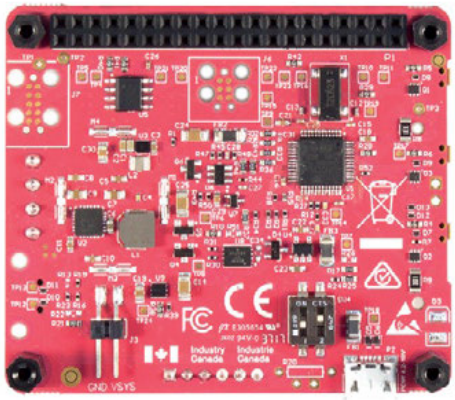
£10 / $13

magpi.cc/2xyhCYH

pijuice.com

From £25 / $33





SOLAR POWER

PiSupply also sells a Solar kit (£65/$86) which comprises a PiJuice and a specially made 6 W solar panel to charge it out in the field. The latter folds out of a soft case, with a pull-out flap that can be used to hold its twin mini panels at an angle. You'll probably need bright direct sunlight to provide a good level of current (about 1 amp at most) – ours was weak when we tried it out on a grey autumn day – but it's a nice option. We were also supplied with a 40 W version (with six mini panels) which should provide a greater current output and, with twin USB ports and a barrel jack, could be used to charge several devices at once.

What's my level?

One thing we soon noticed was a disparity in the displayed battery level when charging – via the GPIO pins of the mains-connected Pi or the PiJuice's own micro USB socket. As soon as we unplugged the power, the status level dropped rapidly by around 20%. According to PiSupply, this is a known quirk of the protection circuitry in Li-ion batteries and the specific 'fuel gauge' IC used by the PiJuice, and the actual battery discharge rate is fairly linear. So, a bit confusing but nothing to worry about. In addition, an RGB status LED gives a rough guide to the battery level, flashing blue during charging.

> "A much neater solution than most portable power methods – no messy wiring here"

So, how long does the battery last? We performed a simple uptime test with a Python script that periodically logged how long the Pi had been running. On an idling Pi 3, it averaged around 4 hours. A little shorter than we'd hoped for, but on a Pi Zero or A+ you should be able to achieve near double that. To extend battery life, you could also make use of the wake-up alarm feature in the GUI config options, to turn a shutdown Pi back on at a specific time or even charge level.

Another interesting option is the watchdog timer that monitors a software 'heartbeat' and, if it's not heard for a certain period, automatically resets the Pi – ideal for when you can't physically reach it to do a hard reset following a crash. There's also an array of system event scenarios for which you can trigger events, including custom functions – just add the path to your own script under User Scripts.

Further options include changing the battery profile (to one of several presets or a custom configuration), updating the firmware, and choosing the functions of the board's two LEDs. Lastly, you can set the functions for the three tiny push buttons on the side of the PiJuice – individually for press/release, single press, double press, and two long-presses (with customisable time parameters). By default, the SW1 button can be long-pressed for 10 seconds to safely shut down the Pi, and then pressed to restart it – another greatly appreciated feature.

Last word

As well as an all-in-one portable power solution that's far neater than the alternatives, the PiJuice offers advanced power management features with an impressive number of settings and custom options for maximum versatility. Three user-definable push buttons and a built-in real-time clock are a major bonus.

★★★★★

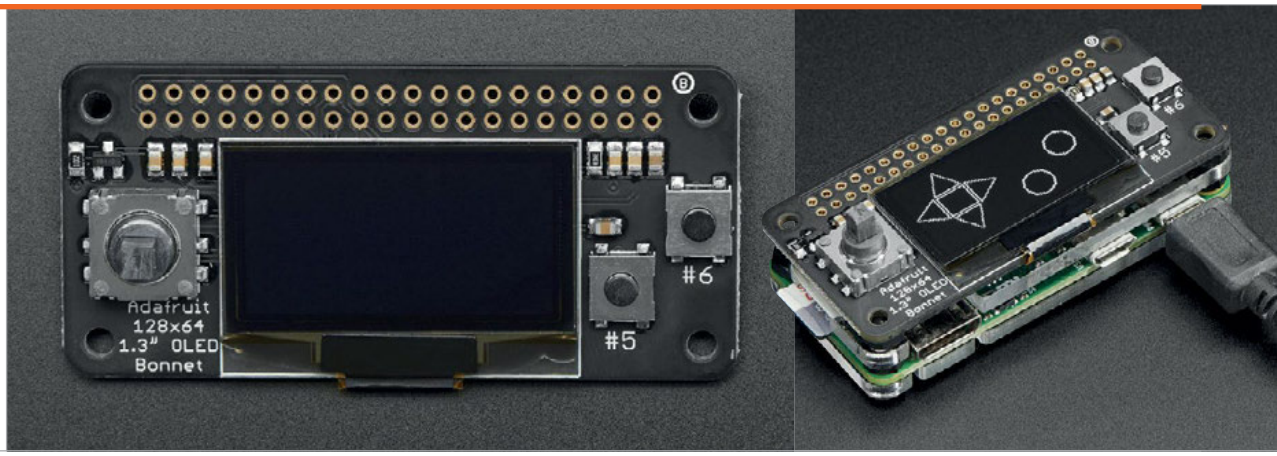
magpi.cc/2xzuC3h

£24 / $32

Maker Says

"A compact display, with buttons and a joystick"

Adafruit



128×64 OLED BONNET

A high-contrast mini OLED display, complete with controls

Looking for a low-power yet bright mini display for your Pi project? Adafruit's latest OLED screen could well fit the bill. An OLED (organic light-emitting diode) display offers high contrast combined with a low power draw, since it doesn't require a backlight.

While numerous OLED screens are available, including a range from Adafruit itself, most require you to wire them up manually to the Raspberry Pi (or whatever device you're using). The Pi Zero-sized OLED Bonnet takes the hassle out of connection: pre-assembled with a female header, it simply slots onto the Pi's GPIO pins.

Available from Pimoroni in the UK, the OLED Bonnet is the big sibling of the 128×32 PiOLED (**magpi.cc/2xAq7po**), doubling the latter's screen area while adding a mini joystick (four-way plus central push function) and two buttons. This would make it ideal for use as a mini menu system in, for example, a music player.

While the screen is monochrome – white on black – and obviously too low-res to use as a main Pi display, its high contrast enables it to show text with great clarity. Any standard TTF font can be used, and one of the Python examples downloaded after cloning the relevant GitHub repo is an old-school sine-wave scrolling text demo. Basic images, which may be converted to bitmaps and resized via PIL, can also be displayed.

Unlike an e-ink screen, the OLED Bonnet is even able to handle basic animations. While the frame rate is rather sluggish by default, it can be speeded up to about 15 fps by raising the I²C core baud rate to 1 MHz in the Raspberry Pi's **/boot/config.txt** file.

As well as two GPIO pins for I²C communication with the Pi, the OLED Bonnet uses seven others for joystick and button inputs. That still leaves plenty of GPIO pins available for use in projects, although due to the full-size female header, you'll need to break them out using something like a Pico HAT Hacker.

Last word

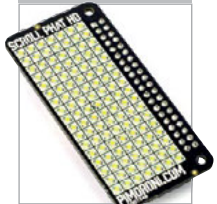
With its high contrast and clarity, the OLED Bonnet is ideal as a mini status display or – taking advantage of the joystick and buttons – menu system. The screen's low power draw (around 40 mA on average) is also an advantage for portable projects using battery power.

★★★★☆

Related

SCROLL PHAT HD

Packing 17×7 white pixels, with full PWM brightness control, this display is ideal for scrolling text messages.



£12 / $16

magpi.cc/2wShYcf

magpi.cc/2zfbbLq

£6 / $8

Maker Says

"Monitor all of the things!"

Pi Hut

STATUS BOARD

Keep an eye on projects with this dry-wipe marker HAT

The Status Board from Pi Hut is one of the most fundamentally simple ideas we've seen. It has five dry-wipe strips sitting next to controllable LEDs. A smaller (and slightly cheaper) Status Zero board has just three strips.

With the board attached to a Raspberry Pi, you get a simple status notification board. You write the name of the item being monitored on the dry-wipe strip, and use code to light up the LEDs. There are two LEDs next to each strip: one green and the other red (making ten alerts in total).

"It's such a fine line between stupid and clever," as a wise man once said. It may well be easy to dismiss such a basic board, but it has many uses and comes with lots of code examples. The Pi Hut suggests using it as a server status, and to monitor WiFi networks or email inboxes. You could also hook it up to weather or transport line information. In fact, anything for which you can imagine a need for a label and a light. And perhaps a button.

To the right of each strip are two pin holes so you can connect a button. The status lights can be programmed to react to button pushes or wait until a button is pressed.

Setup is remarkably simple. You simply affix the board to the GPIO pins on your Raspberry Pi. Of course, with the Pi Zero, you'll also need to solder the pins onto the board.

The only thing easier than setting up the board is using it, thanks to support from the GPIO Zero library (**magpi.cc/2ysqzqm**). Simply import the **StatusBoard** method from GPIO Zero and then create a StatusBoard object (here called **sb**) to control.

```
from gpiozero import
StatusBoard
sb = StatusBoard()
```

Then use **sb.on()** and **sb.off()** to turn all the lights on or off. Or control each strip and LED individually using **sb.one.lights.green.on()** and so on. You can blink and pulse the lights, and rename the 'one,' 'two,' 'three' labels to something more meaningful for your code, such as 'London' and 'Cambridge.'

The Pi Hut has a comprehensive tutorial on GitHub (**magpi.cc/2ysWw1U**) along with a whole bunch of code examples, including a London Tube Line status board and a Donald Trump news alert.

Last word

It's incredibly basic, but the Status Board has charm and is very easy to use. It's a good device for learning about various online data service APIs and how to respond to data points with a board.

★★★★☆

Related

PAPIRUS ZERO

Add an e-paper display to your Raspberry Pi and use it to display a status message indefinitely, without using any electricity.

£26 / $35

magpi.cc/2goftfw

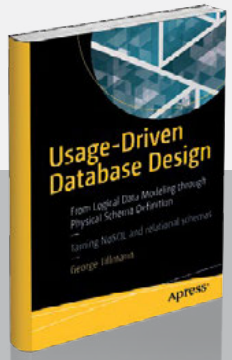
RASPBERRY PI BESTSELLERS

DESIGNING FOR DATA

The Internet of Things generates unprecedented levels of data: learn how to handle more...

USAGE-DRIVEN DATABASE DESIGN

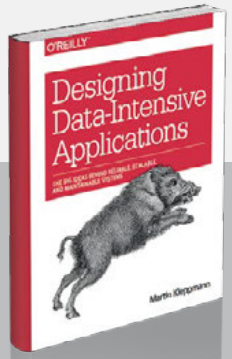
Author: George Tillmann
Publisher: Apress
Price: £27.99
ISBN: 978-1484227213
magpi.cc/2x14taj



A framework that combines the static logical data model with the dynamic flow of the process model for a practical solution across different database management systems.

DESIGNING DATA-INTENSIVE APPLICATIONS

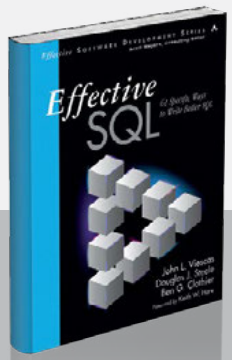
Author: Martin Kleppmann
Publisher: O'Reilly
Price: £35.99
ISBN: 978-1449373320
magpi.cc/2x1rNoc



If you've got a lot of data, it's time to choose between the trade-offs in consistency and availability. Kleppmann brings practical experience and useful theory to his explanations.

EFFECTIVE SQL

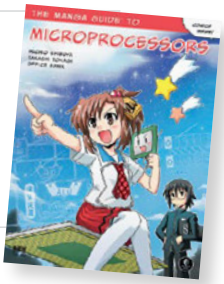
Authors: John L Viescas, Douglas J Steele, Ben G Clothier
Publisher: Addison-Wesley
Price: £35.99
ISBN: 978-0134579061
magpi.cc/2x1Jns5



There's plenty of mileage left in RDBMS (and N1QL shows that SQL will live into the NoSQL age). *Effective SQL* will fill in gaps in your SQL problem-solving knowledge.

THE MANGA GUIDE TO MICROPROCESSORS

Authors: Michio Shibuya, Takashi Tonagi, Office Sawa
Publisher: No Starch
Price: £19.99
ISBN: 978-1593278175
magpi.cc/2x14laP



You may have been wondering how the processor inside your computer works, but were you looking for a guide in manga format? Surprisingly, framing the explanations around cartoons and a slightly contrived story involving two Japanese school students – a computer genius and a shogi (Japanese chess) prodigy – works very well. The narrative framework supports a well-ordered and worked through set of explanations, which should enlighten both techies and intellectually curious non-coders.

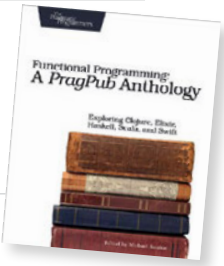
Starting with simple explanations – like arithmetic operations versus logic operations, and the gates and Boolean logic that make up the latter – Shibuya and his team show the parts of a relatively simple CPU, what they do, and how they do it. The relatively matter-of-fact technical explanations enabled by the story ensure that everything from bitwise operations to variations on flip-flop circuits can be absorbed by the reader. Even the circuit architecture of the TI 74S181 microcontroller is not too frightening.

By the end, the reader will have a real appreciation of opcodes, the stack, memory addresses, branch instructions, status flags, and everything else that makes a set of zeroes and ones move through tracks of silicon in such useful ways. Recommended!

Score ★★★★★

FUNCTIONAL PROGRAMMING: A PRAGPUB ANTHOLOGY

Author: Michael Swaine
Publisher: Pragmatic Bookshelf
Price: £38.50
ISBN: 978-1680502336
magpi.cc/2x1s7n1



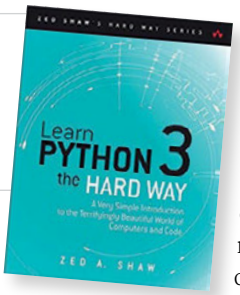
Here's an idea for trying to explain functional programming (FP). Take several articles on FP by different writers from 100 issues of PragPub magazine, each covering different languages and approaches to FP. Add in a short interview with Rich Hickey (creator of Clojure), and build towards more advanced concepts. This should give readers a broad appreciation of FP, and an idea of which language to choose for a more involved exploration.

After explaining why FP has recently become so important (spoiler: immutable data makes concurrent programs easier to reason about), Scala – which bridges object orientation and FP – makes a gentle introduction, before the Clojure section shows how programming changes when data and code are interchangeable. Elixir, bringing Ruby's winning style to Erlang's Beam VM, provides a gentle introduction to pattern matching (which returns later), functions, and concurrency.

Haskell brings functional thinking, with data and data types foremost. Swift is the surprise guest here, with some strongly functional features. These five languages are then used for 'going deeper' into functional thinking (plus a surprise appearance by Lua). By combining articles from several PragPub authors, many concepts get a good airing. While the approach is not always cohesive, the overall effect is fairly enlightening.

Score ★★★★½

LEARN PYTHON 3 THE HARD WAY



Author: Zed A Shaw
Publisher: Addison-Wesley
Price: £21.99
ISBN: 978-0134692883
magpi.cc/2x1530v

Zed Shaw is a no-nonsense professor, who knows where the student needs to go, where she is now, and how to guide her along the path to learning. The 'hard way' of the title is typing in the examples (copying and pasting won't fix programming into your brain or muscles). The parallel is with scales and arpeggios repeated often while learning a musical instrument: running the programs, and finding and fixing your mistakes along the way.

Not everyone will learn best this way, but many (if not most) people can finally learn programming over the course of Shaw's 52 exercises and accompanying study drills. Along the way there are pauses to review what's been learned so far. Much of the coverage is of the expected (and necessary) topics, but chapter 23's deep look at character encoding, and non-Latin alphabets, is one example of Shaw going above and beyond the expected content.

Although you need discipline to stay the course and stick to the study drill, wings will be stretched by the later sections. Give it a go – and if you really don't like it, pass it on to someone else and get yourself a copy of *Head First Python* – but give *Learn Python 3 The Hard Way* a good try first.

Score ★★★★☆

THE DATA SCIENCE HANDBOOK

Author: Field Cady
Publisher: Wiley
Price: £48.50
ISBN: 978-1119092940
magpi.cc/2x168N8

We all know that the world needs more data scientists – and it's a very lucrative career – but the breadth of skills required is daunting: strong maths, in particular (but not limited to) statistics; programming skills; domain knowledge for various businesses; data wrangling; and presentation. But a meaningful introduction is possible, even in 400 pages, given a clarity of view of the data science field, and the problems tackled by bringing code to big messy data sets.

That mess of data is a ubiquitous problem for data scientists. After encouraging the reader to first frame the problem by asking the right questions – and negotiate a clear idea of what 'done' might look like – Cady gives a set of questions to ask about the data, and techniques for dealing with it. The language roundup favours Python and its libraries. Pandas – with DataFrame and Series – is quickly introduced, followed by visualisation.

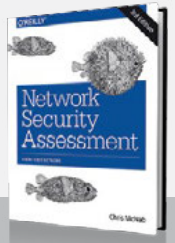
A good chunk of machine learning, and a nicely relevant chapter on presentation, round off the first section. Then it's time to tackle specialised but necessary knowledge including data encoding, unsupervised learning, NLP, probability, and even a look at performance. This is a well-rounded introduction that will leave you ready to start tackling real data science problems.

Score ★★★★☆

ESSENTIAL READING: NETWORK SECURITY

They're out to get you! Don't stick your head in the sand – learn the attacks and defences.

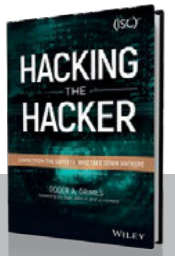
Network Security Assessment



Author: Chris McNab
Publisher: O'Reilly
Price: £39.99
ISBN: 978-1491910955
magpi.cc/2x1kY69

An update of the O'Reilly classic, with a comprehensive treatment of most of the threats you should be worrying about.

Hacking the Hacker



Author: Roger A Grimes
Publisher: Wiley
Price: £20.99
ISBN: 978-1119396215
magpi.cc/2x1dJuR

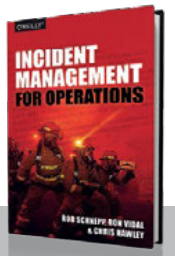
Get a different insight into security through short ethical hacker bios, and profiles of various attack techniques. Fascinating.

Penetration Testing Essentials

Author: Sean-Philip Oriyano
Publisher: Sybex
Price: £42.50
ISBN: 978-1119235309
magpi.cc/2x26KSA

Learn the tools for attacking your own network – broad coverage, but beginner-friendly.

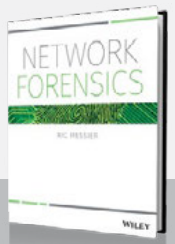
Incident Management for Operations



Authors: Rob Schnepp, Ron Vidal, Chris Hawley
Publisher: O'Reilly
Price: £27.99
ISBN: 978-1491917626
magpi.cc/2x1FHqi

Built on Jesse Robbins's adaptation of firefighter techniques for managing emergency incidents – essential preparation for unplanned interruptions.

Network Forensics



Author: Ric Messier
Publisher: Wiley
Price: £50.00
ISBN: 978-1119328285
magpi.cc/2x1sQo8

A hands-on guide to investigating network breaches that will give you all the theory you need, too.

NOTAGRAMA INTERVIEW

This unique music reader that uses the Raspberry Pi and a camera is the creation of **Daniel Marcial**. We talk to him about his project

The subject of a developing crowdfunding campaign, Notagrama caught our eye last month as a really interesting way of teaching music on the Raspberry Pi in a way very different to Sonic Pi. We reached out to creator Daniel Marcial to chat about it.

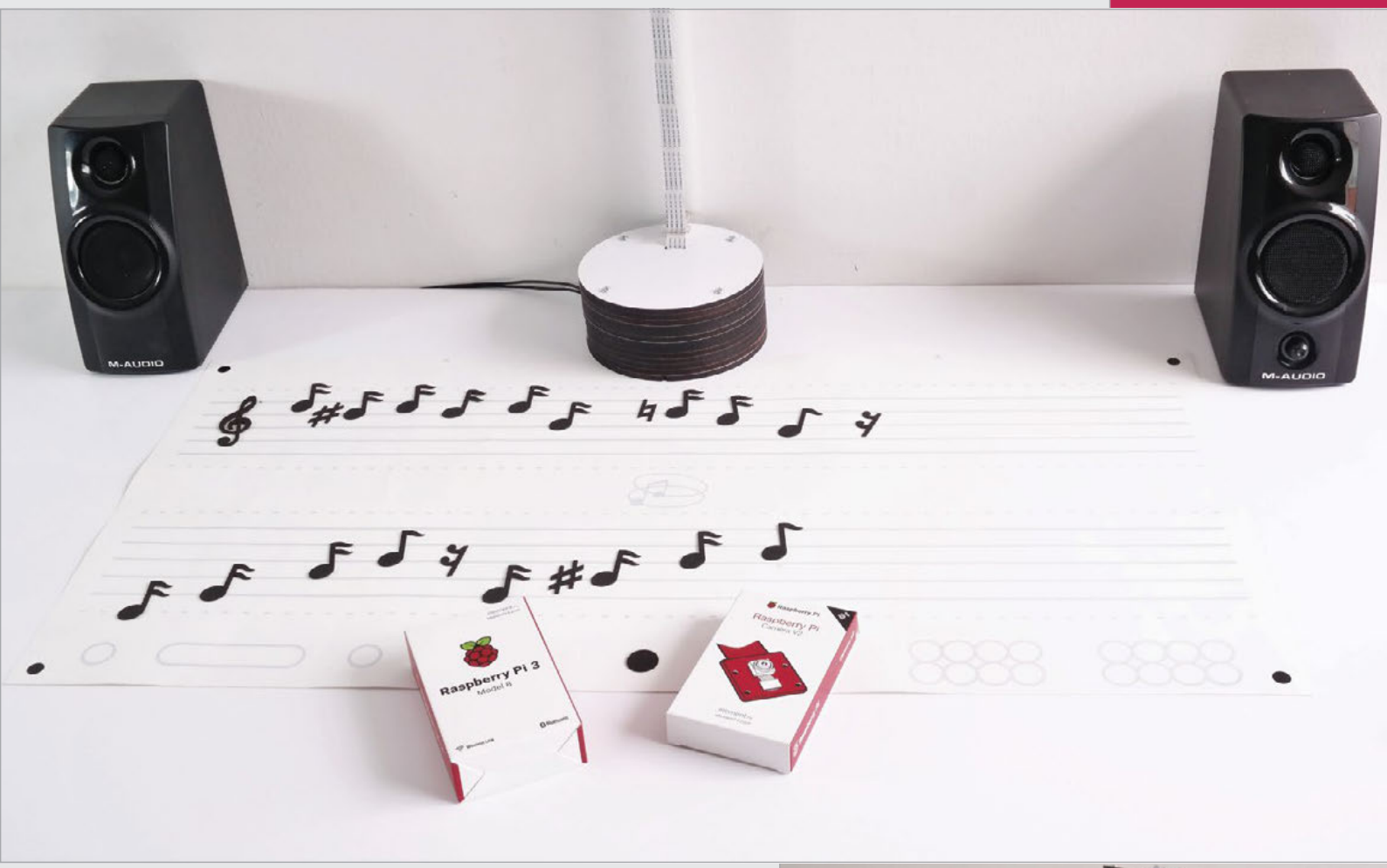
What is Notagrama?
The Notagrama is an educational product consisting of a large sheet with two staves, chips in the form of musical symbols, and a computer capable of reproducing the melody formed by the chips. It works with machine vision technology: it has a camera placed above the sheet with which the computer determines the position and shape of the chips to constitute a melody and reproduce it by the speakers. The Notagrama can be used to practise reading and writing scores, composing melodies, imparting music classes, or to have fun playing with musical notes. It is a project that allows interaction with musical symbols in a tangible and innovative way.

What's your music background?
I studied piano for six years and I've been playing since I was nine years old. I have also taken courses on music production, mixing, harmony, and singing. I like playing the piano and composing music with Ableton Live.

Below The Pi and Camera Module make up the majority of the tech behind the Notagrama project

Daniel Marcial

Occupatiuon: Teacher, musician

How did the idea come about?
When I was at university, I made a project with machine vision technology: a score system for a real pool game. I liked the machine vision concept, so I wanted to build a music application with it. First I made sequencers and sliders with chips and illustrations, and afterwards I replaced circular chips with music symbols. That's how Notagrama started.

Above The 'chips' are notes you can place on the sheet. These are read by the Pi

Why use the Raspberry Pi?
I like Raspberry Pi because it's very accessible and cheap. The most important thing for me is the large amount of information on the web about it. I built the Notagrama prototype with my first Pi, a Raspberry Pi 3.

> "Notagrama allows interaction with musical symbols in a tangible and innovative way"

Have you ever used Sonic Pi?
Yes, I have used it. I like it because it's a very different way to compose. I have composed music in the traditional way, but when I discovered Sonic Pi I found a new way to do it. It's very funny to listen your code!

What are your hopes for Notagrama?
I want to see a Notagrama in music classes around the world. I would like to know that I have contributed to the world's music student community.

Anything else you want to add?
I want to invite you to follow my social networks – if there are some educators interested in collaborating on my project, we can talk! (**facebook.com/danielmarcial22**, **youtube.com/danielmarcial22**, Instagram: **danielmarcial22**)

FOLLOW DANIEL

Want to check out Daniel's work and maybe collaborate with him? You can follow him on social media and YouTube under his handle **danielmarcial22**.

THE MONTH IN RASPBERRY PI

Everything else that happened this month in the world of Raspberry Pi

FRIGHTFULLY GOOD PI PROJECTS

THESE SPOOKY HALLOWEEN PROJECTS ARE ABS-GHOUL-UTELY TERRIFIC

We didn't bring you a Halloween feature last month, breaking our recent streak of doing them. Fear not, though: we've been on the lookout for the scariest and most inventive Raspberry Pi Halloween projects from the community. Feast your eyes on these terrifying treats.

POSSESSED PORTRAIT

magpi.cc/2yMfQrl

The picture for this project doesn't really do it justice, so take a quick look at the video: **magpi.cc/2yMgAgu**. It's a very effective and scary project that uses a little illusion and a motion sensor to make you think the painting is moving. And attacking.

THE POPLAWSKIS' HOLIDAY FRIGHTS

magpi.cc/2yMfIse

Control the Halloween decorations on the Poplawkis' lawn. There's a camera recording the whole thing, and you can control one decoration for a minute at a time for 10¢. Keep an eye on it during actual Halloween night to scare the plastic masks off unsuspecting trick-or-treaters.

HAUNTED JACK-IN-THE-BOX

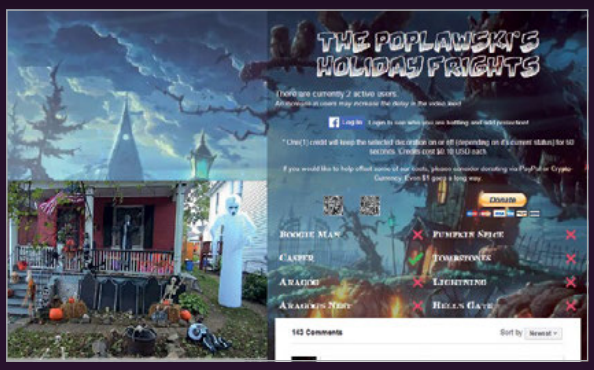
magpi.cc/2yMcogZ

This automated jack-in-the-box uses a camera to detect if someone is around. If you turn up in front of it, surprise! Pop goes the weasel and also about three years off your life. Put it in an inconspicuous part of your house to scare the bejeesus out of friends and children.

HALLOWEEN MAGIC MIRROR

magpi.cc/2yKRn6c

One of the first traditional magic mirror projects we saw had some timed functions such as showing a scary face during Halloween. This one takes it a step further by making the mirror actually look like a normal mirror… until a phantom appears.



SAVE THE PLANET WITH P.A.'S COMPETITION

PA Consulting's 2018 competition is now open – win £1000 for your school or college

Want to save the planet with a Raspberry Pi and earn £1000 for your school in the process? Then the PA Consulting Raspberry Pi competition for 2018 may be just what you're looking for...

These PA Raspberry Pi competitions have been going on for five years now, with 2017's teams being tasked with creating projects that would help those with disabilities. There were some amazing entries, such as the junior school winners who invented a system to help deaf-blind people know when someone is at the door.

"The new theme is sustainability." PA announced. "We're challenging you to use the Raspberry Pi to invent something that will help save the planet."

Be a Planeteer

What exactly is sustainability in this context? PA further explains:

"The main threats to our planet centre around energy use, food production and scarcer resources. So we're interested in inventions that could help meet those challenges. Maybe a football that stores the energy created by every kick. Or a scanner that helps us cut food waste. Or a bin that automatically recycles paper. Let your imagination run wild and see what inventions you can come up with. We know from previous years that you'll come up with some great ideas and we're looking forward to seeing them."

The rules

There are three categories for the competition, separated by age group:

- **Primary School Award:** academic years 4–6
- **Secondary School Award:** academic years 7–11
- **Sixth Form & College Award:** academic years 12–13

Each category winner gets £1000 for their school or college, and the first 100 entrants get a free Raspberry Pi starter kit. The competition is open to all schools and colleges in the UK and ends on Monday 5 March 2018. You can register here: **magpi.cc/2zcyFRg**

2017 WINNERS

Here are the winning projects from last year

PRIMARY SCHOOL AWARD

A door entry system paired with a wearable device that helps deaf-blind people identify visitors to their residence.

SECONDARY SCHOOL AWARD

A monitoring tool for carers of elderly people to address the risks of unattended falls.

SIXTH FORM & COLLEGE AWARD

A learning game designed to assist and support those with attention-deficit disorders and dyslexia.

HELP RASPBERRY PI CELEBRATE ITS BIRTHDAY!

The Raspberry Pi Foundation wants to put on a global celebration for its sixth birthday – here's how you can help!

For the last few years, we have held a big Raspberry Pi community event in Cambridge around Raspberry Pi's birthday, where people have come together for a huge party with talks, workshops, and more. We want more people to have the chance to join in with our birthday celebrations next year, so we're going to be co-ordinating Raspberry Jams all over the world to take place over the Raspberry Jam Big Birthday Weekend, 3–4 March 2018.

Big birthday fun

Whether you've run a Raspberry Jam before, or you'd like to start a new Jam in your area, we invite you to join us for our Big Birthday Weekend, wherever you are in the world. This event will be a community-led, synchronised, global mega-Jam in celebration of our sixth birthday and the digital making community! Members of the Raspberry Pi Foundation team will be attending Jams far and wide to celebrate with you during the weekend.

Jams across the world will receive a special digital pack, and we'll also be sending out party kits to registered Jams.

RASPBERRY JAM

Get involved

If you're keen to start a new Jam, there's no need to wait until March – why not get up and running now? Then you'll be an expert by the time the Raspberry Jam Big Birthday Weekend comes around. Visit **rpf.io/jam** for more information, and submit your event to the map when you're ready.

Once your Jam is up and running, register it for the birthday party: **rpf.io/bdayjamform**.

If you don't fancy organising a Jam for our Big Birthday Weekend, but would still like to celebrate with us, keep an eye on our website for an update early next year. We'll publish a full list of Jams participating in the festivities so you can find one near you.

NEED HELP STARTING A JAM?

First of all, check out the Raspberry Jam page to read all about Jams, and take a look at our recent blog post explaining the support that we offer: **rpf.io/jam**.

If there's no Jam near you yet, the Raspberry Jam Big Birthday Weekend is the perfect opportunity to start one yourself! If you'd like some help getting your Jam off the ground, we've produced a free Raspberry Jam Guidebook full of advice gathered from the amazing people who run Jams in the UK. Download it from **magpi.cc/2q9DHfQ**.

If you have more queries, email: **jam@raspberrypi.org**.

KICKSTART THIS!

The best crowdfunding hits this month for you to check out...

LORANGA

kck.st/2hAfVaA

A special board for IoT, this add-on allows the Pi to easily connect to the LoRa IoT network. It uses mobile network data to connect to the internet, which allows for long-range and low-cost communication. It's completely open source (it even has open hardware) and at the time of writing it's very close to its goal, so take a look if you want to extend your IoT.

I'M BACK

kck.st/2xSyvRi

A 'second chance' for your old analogue camera, I'm Back is a special product that transforms cameras that take 35mm film into a digital camera thanks a Raspberry Pi Zero. This means you can use the lenses and other great equipment for your old camera while still making digital photos. There's a more advanced version as well that uses proprietary hardware if you're more inclined.

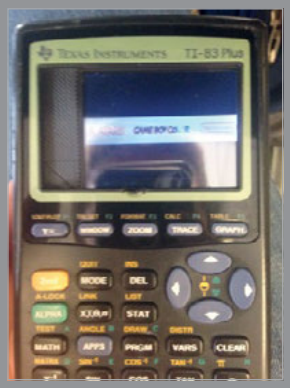
BEST OF THE REST

Here are some other great things we saw this month

magpi.cc/2hI5XRf

GAMING CALCULATOR

While we obviously don't condone ignoring your teacher to play games, this calculator hack with a Pi and RetroPie is pretty genius.

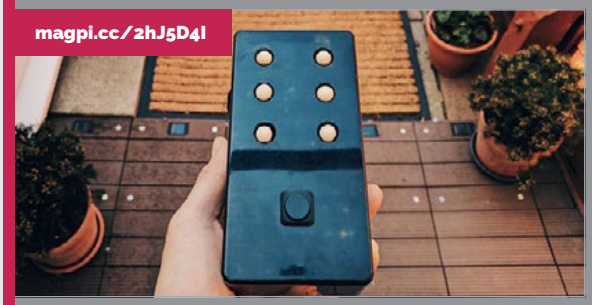


magpi.cc/2hIp2CJ

VHS PI

We love a bit of retro upcycling and weird Pi cases, so we were immediately drawn to this VHS tape that has a Pi inside. There's access to the SD card on one side, and a USB hub on the other. Lifting up the flap at the front exposes the I/O ports as well. It's a lovely and fun build.

magpi.cc/2hJ5D4I



BRAILLEBOX

Accessibility in tech is something a lot more people should be familiar with, so it's cool to see this excellent project that turns text from news feeds into Braille so people with visual impairments can read the news like the rest of us. Lovely.

NEW YORK WORLD MAKER FAIRE

Fun at the faire with makers from around the globe!

The kids were keen to see what they could do with code

When we think of Maker Faires, the first image that pops up is that of people showing off their amazing inventions. It's usually full of huge fire-breathing dragon vans, electronic sculptures, complicated wooden machinery and the like. That's only one side of Maker Faires, though – stalls were also showing off medical applications for new tech, hydroponic projects from school students, and even educational tech. That last category is where the Raspberry Pi Foundation's stall fell, debuting a brand new demo to help 'plant seeds' of computing enthusiasm into hundreds of young minds.

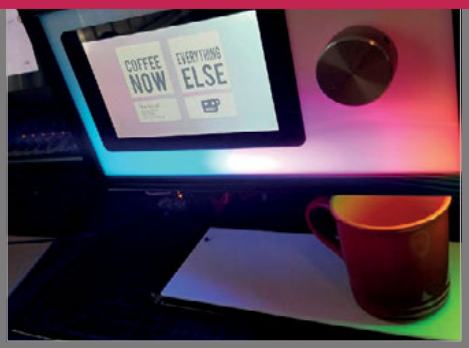
The Raspberry Pi demo was quite simple. People were presented with three different wooden blocks with a Raspberry Pi, LED, or button attached to them. Nails were connected to the GPIO pins on the Pi and the connectors of the components, and the challenge was to use crocodile clips and Python to get the Pi to interact with the light or button. Activity sheets walked people through it, and while this might seem easy to readers of *The MagPi*, it was something a lot

FAIRE HIGHLIGHTS!

Here's just a small taste of some of the cool stuff we saw

CRICKET PI

Next to the Raspberry Pi booth, young maker Jieruei Chang showed off his special Pi project that uses voice control to create MIDI backing tracks for violin playing. It's a cool project and provided a lovely soundtrack to the weekend.



MUGSY

A robot coffee maker? Yes please. As long as it grinds the beans fresh and makes sure the water is the perfect temperature before brewing. Also, if it could just then wheel over and hand cups to us every hour, that would be great.

KERMIT THE FROG

We're not sure if this is Pi-powered but we love it anyway – the ubiquitous leader of The Muppets was cycling around the Faire and enthralling everyone. We especially like the letter blocks he uses to reach the pedals. It's not easy being green, after all.

Local Raspberry Pi Certified Educators gave talks in how to use the Raspberry Pi for learning

People of all ages tried out the project at our booth

of kids had never done before. We supervised many young people being wowed at how easy it was to get the LED to blink, or have a eureka moment as they worked out how to go beyond the activity sheet and get the button to control the LED.

The booth was surrounded by other Pi projects and stalls, including one for Piper, the laptop you build yourself and then use to learn about physical computing through Minecraft. The area was packed for both days of the Faire, but we managed to break off for a couple of times to explore the rest of what was on offer.

> "Educators and parents left with aspirations to help teach young people"

Use of the Raspberry Pi was seen throughout the Faire, whether it was in the block of tables dedicated to medical equipment, or visible on many robots in the corner dedicated to them. Inside the New York Hall of Science, some Pi projects that have previously appeared in the magazine were on show, including the digital film converter.

The venue was huge and it took us a couple of days to see it all. As well as cool projects on show, many people were there selling cool and unique items like cardboard pinball machines, PVC pipe dart guns, custom 3D prints, and more. Whether you like the creative or technical side of making, there was something there to have a look at – and that's before you got to the custom go-kart races and drone flying races.

It was a fun event – although hot – and many kids went home inspired, while a lot of educators and parents left with aspirations to help teach young people about digital making. And that's the primary goal of Raspberry Pi.

HISTORIC FLUSHING MEADOWS

The site of the World Maker Faire is Flushing Meadows Park in Queens, New York. It's an important site for lovers of tech as it was also the location of the famous 1964 World's Fair.

The Space Age was taking off, with humankind a few years away from landing on the moon but reaching for it, and a lot of what was on show here reflected that. Walt Disney, a great lover of World's Fairs, had a big presence here: he debuted his Abraham Lincoln robot (or audio-animatronic) at the Illinois state pavilion in a little show called Great Moments with Mr Lincoln. It was a massive advancement in lifelike robotics, and you can still see an updated version of that show in Disneyland.

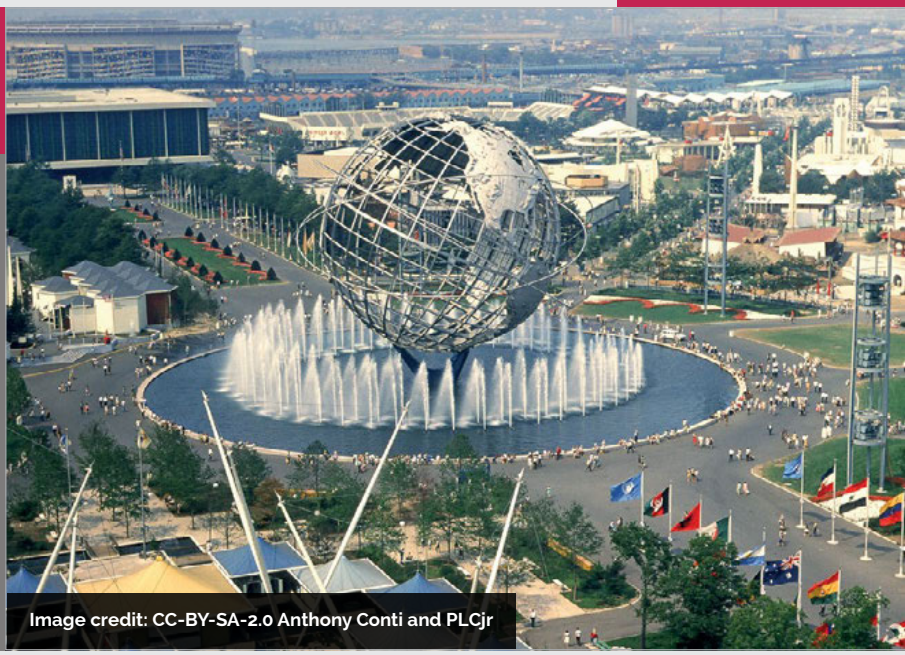


Image credit: CC-BY-SA-2.0 Anthony Conti and PLCjr

COMMUNITY PROFILE

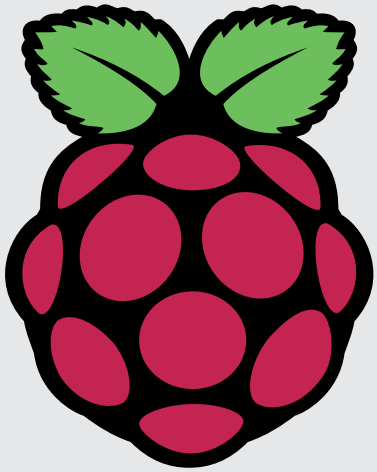
PAUL BEECH

Creator of the Raspberry Pi logo, maker of things, and Pirate Captain of Pimoroni

Paul Beech

Category: Pirate Captain
Day job: Co-owner of Pimoroni
Website: twitter.com/gurupimoroni.com

Below Paul is the designer of the official Raspberry Pi logo, using self-taught skills in graphic design to create the winning competition entry



Paul Beech's experience with coding can be traced back to early days of typing programs into his brother's ZX81. This experience thoroughly hooked him onto computing, with the likes of the MSX, C64, Amiga, and Archimedes making appearances in his day-to-day life. From there, he studied briefly at university before teaching himself graphic design in Corel Xara and Adobe Illustrator – something that would play a big part in his early role within the Raspberry Pi community.

Winning design

An early Raspberry Pi article by BBC tech journalist Rory Cellan-Jones caught Paul's interest and directed him toward the upcoming device and the blog entries surrounding its future release. And on 5 August 2011, Raspberry Pi's Director of Communications, Liz Upton, put out the call for someone to design a logo for the brand. Paul won the competition.

"I followed all the news, and when the competition was posted on the blog I went for it," explains Paul when thinking back to his conception of the now highly recognisable logo. "I struggled with concepts that used the Greek letter π or any kind of actual pi. I knew that a big idea like a computer for $25 needed a logo that was simple and bold and could be photocopied in black and white five times and still be recognised from across a room. As soon as I stopped trying to include the 'Pi' bit and just went for 'Raspberry', it got a lot easier."

Paul submitted his design idea, along with some supporting material, and despite his confidence in the design, he's still having issues coming to terms with the fact that he won. "It's never quite landed."

Paul, Jon, and the Pimoroni team have made waves in the Sheffield industry, consistently ranking high as a major influence within the creative scene

Sheffield-based Pimoroni are also the UK's largest Adafruit reseller. As well as being cartoon pirates, of course

"We want to solve problems we have in a way that's helpful to a bunch of people. We want everyone to be able to tinker and play and learn"

The Picade's panels are powder-coated in black so the end result feels like a finished, quality product

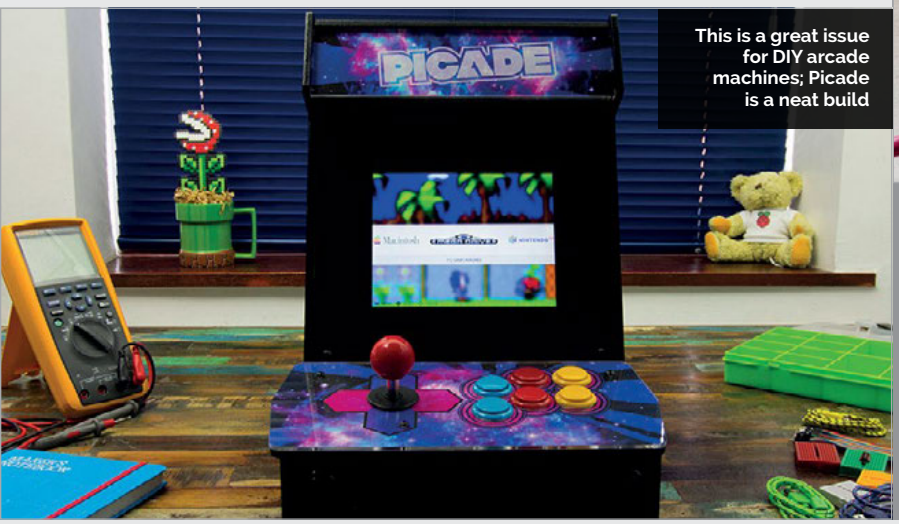
Pirates launch

Prior to this step into the community, Paul was already becoming a sound digital maker. Having met Jon Williamson in 2003 at a LAN party, the two instantly clicked and spent their free time tinkering while filling their days with web and startup work. When the Raspberry Pi came to the retail market in 2012, the pair made their mark by creating the Pibow, a multilayer, laser-cut case for the Raspberry Pi. "After we complained about early cases, we thought someone should do something about it. Eventually we realised that we probably should be those people."

Above "We want to solve problems we have in a way that's helpful to a bunch of people. We want everyone to able to tinker and play and learn"

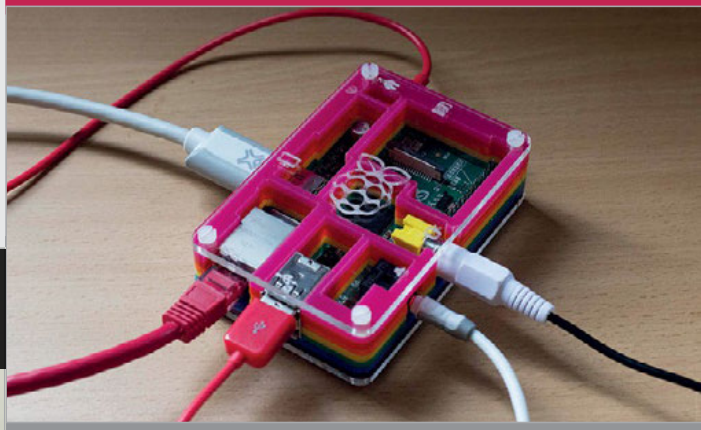
From the success of the Pibow, the pair went on to launch the crowdfunding campaign for the Picade, a Raspberry Pi arcade machine kit build, and from there, Pimoroni was born. "We brought our web and design and geek thing to the making and tinkering world and it felt right and good and is the best thing we've ever been involved with."

> "We brought our web and design and geek thing to the making and tinkering world"



This is a great issue for DIY arcade machines; Picade is a neat build

HIGHLIGHT

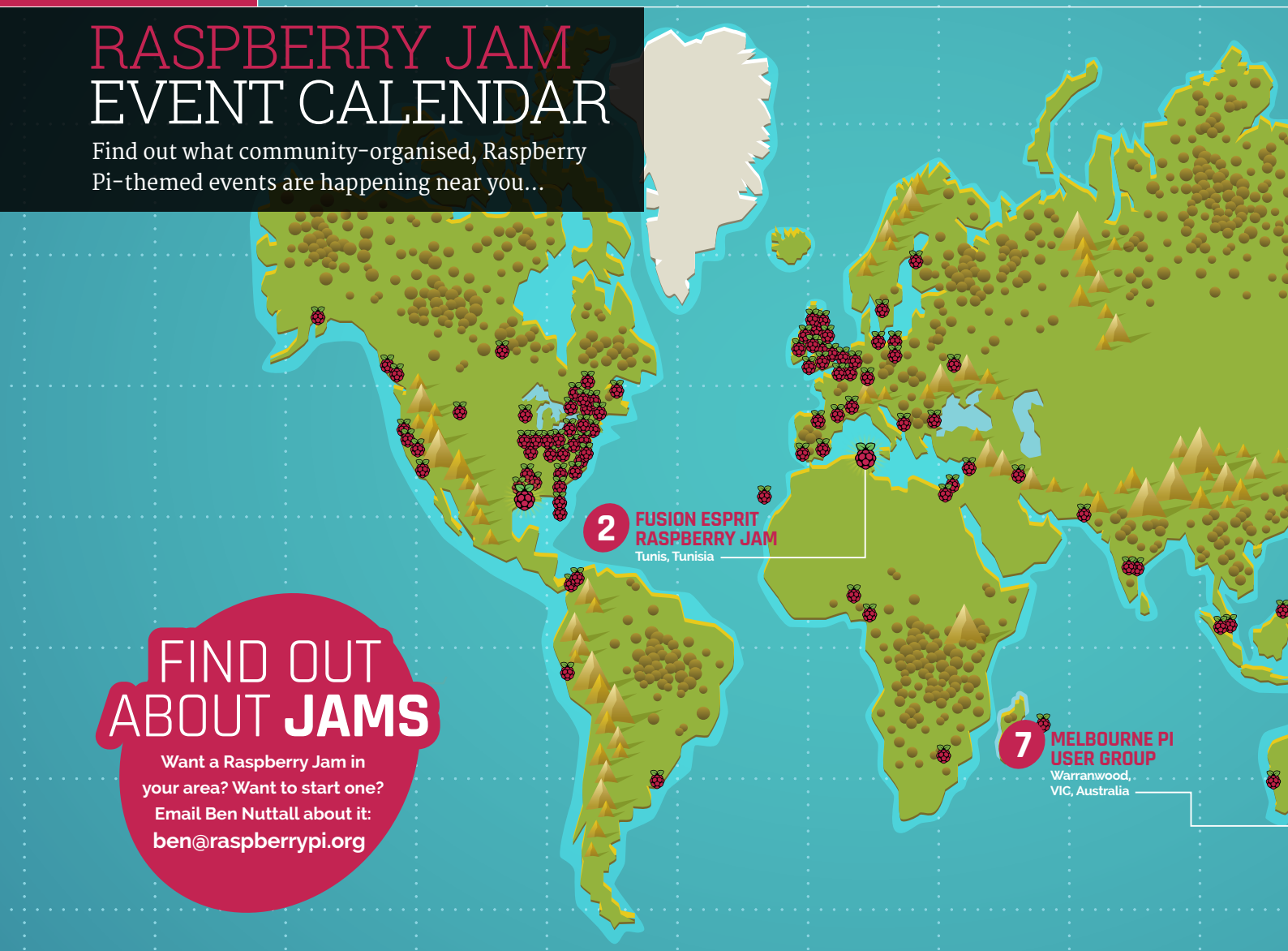


THE COMMUNITY

"I like how many new skills I have and that I get to put positivity into the world," explains Paul when discussing what makes him proud of his role within the Raspberry Pi community, and of others he's met along the way. "The community is amazing and I'm surrounded by lovely, talented people who *know stuff* all the time. We support almost 40 people now at Pimoroni; that's scary and amazing."

RASPBERRY JAM EVENT CALENDAR

Find out what community-organised, Raspberry Pi-themed events are happening near you...



FIND OUT ABOUT **JAMS**

Want a Raspberry Jam in your area? Want to start one? Email Ben Nuttall about it:
ben@raspberrypi.org

HIGHLIGHTED EVENTS

1 COFFEE, CAKE AND CODING

When: Thursday 2 November
Where: King Edward VI Sheldon Heath Academy, Birmingham, UK
magpi.cc/2yN1iIF
Meetings and workshops aimed at sharing good coding practice in a relaxed and informal setting.

2 FUSION ESPRIT RASPBERRY JAM

When: Wednesday 8 November
Where: Esprit – Night Schools, Tunis, Tunisia
magpi.cc/2yLmgYj
Want to know more about the Raspberry Pi? Be shown and taught everything you need to know.

3 SH MAKERSPACE RASPBERRY JAM

When: Sunday 12 November
Where: The Boileroom, Guildford, UK
magpi.cc/2yMwbNm
This Jam is primarily a show-and-tell event where people bring along their projects for others to try out.

4 QUANTUM TECHNOLOGY CLUB

When: Thursday 16 November
Where: Cottage Lane Mission, Ormskirk, UK
magpi.cc/2yMptXI
Make some electronic circuits and control them with simple code on Raspberry Pi or Arduino.

REGULAR EVENTS

5 CORNWALL TECH JAM

When: Saturday 11 November
Where: Cornwall College, Redruth, UK
cornwalltechjam.uk
For all ages and abilities. Ask questions and learn about programming in Scratch, Python, Minecraft, and more.

6 TORBAY TECH JAM

When: Saturday 11 November
Where: Paignton Library and Information Centre, Paignton, UK
torbaytechjam.org.uk
Torbay Tech Jam is designed to be a fun, informal, and family-friendly event, for all ages and experience levels.

7 MELBOURNE PI USER GROUP

When: Tuesday 21 November
Where: Melbourne Rudolf Steiner School, Warranwood, VIC, Australia
magpi.cc/2mx2y7Y
The group's aim is to bring like-minded people together to talk about how they're using the Raspberry Pi.

8 HULL RASPBERRY JAM

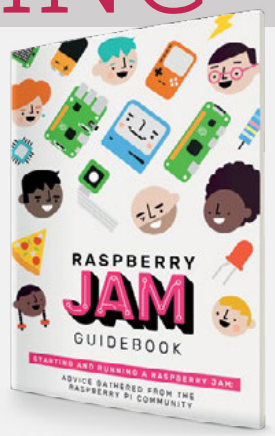
When: Saturday 25 November
Where: Hull Central Library, Hull, UK
magpi.cc/2hIscGC
Get hands-on with digital making activities through workshops and a hackspace area to share projects.

RASPBERRY JAM ADVICE

FUNDRAISING

> "We hand out free raffle tickets while we shake the donation tin. Then we pull winning tickets from a box and they win a prize we've had donated, like a HAT or something."
>
> **Andrew Oakley**
> Cotswold Jam

Every Raspberry Jam is entitled to apply for a Jam starter kit, which includes magazine issues, printed worksheets, stickers, flyers, and more. Download the Raspberry Jam Guidebook at **magpi.cc/2q9DHfQ**.



YOUR LETTERS

Above Etcher is easy to use, but it does have the odd graphical bug

Going headless

I recently got a Raspberry Pi Zero W and wanted to use it headlessly and connect it to my WiFi. This way I can then use it via my laptop without having to attach a monitor to it. I've installed Raspbian to the SD card, but I've run into a bit of a dead-end as I'm unable to set the wireless LAN password without actually connecting it to a monitor. How can I fix this?
Prakash

If you do have access to a monitor, then the good news is you can do the initial setup from the graphical interface and then use it headlessly from then on. All you need to do is connect to your wireless LAN and then open Raspberry Pi Configuration in Menu > Preferences. Find the Interfaces tab and enable SSH, and then go back to the first tab and change the boot method so that it boots into the command line. This way you save a little power.

If you don't have access to a monitor at all, then all is not lost. First of all, SSH can be very easily activated by dropping an empty file called **ssh** or **ssh.txt** into the boot partition of the Raspbian SD card.

For the wireless LAN, you can add another file to the boot partition called **wpa_supplicant.conf** that contains details for your wireless network. This is usually as simple as:

```
network={
    ssid="WiFi name"
    psk="WiFi password"
}
```

But you can check the following link for more info on setting up your wireless LAN connection via the command line: **magpi.cc/2hQhwW4**.

Etcher errors

I have been attempting to burn a copy of the new Raspbian Stretch to my SD card using Etcher. All works well when attempting it from my Linux box, but I have not been successful when running from my Windows 10 box. I have used the same SD card and adapter, as well as downloaded files from Raspberry Pi.

On Linux, things work very well all the way through, but I get an error on the verify section when running on my Windows 10 box. I have been running Etcher as 'administrator' on my Windows box, but no luck.

I am fine burning my personal SD cards on my Linux box, but I am attempting to teach some newbies about the Pi and they only have Windows boxes.

I have successfully burnt SD cards for earlier versions of Raspberry, but Stretch won't work on Windows. Any ideas of what I can do to make things work on Windows?
Lee

This could be something as simple as the download of the Stretch image being slightly corrupted so it doesn't pass the MD5 hash test. Re-download the image and see if you get the same issue.

However, in our experience, Etcher does this regularly on Windows 10 and yet the SD card still works just fine in the Raspberry Pi. Give it a test in a Pi and see how you get on.

English versions of MagPi Mini

I've been collecting every issue of your magazine for a while now as PDFs. I was just checking your back catalogue to make sure I had every issue and noticed that I didn't have the PDFs for *The MagPi Mini*s that were released.

I went to the page and found downloads for the translated versions; however, I was unable to download an English version from the image of the English cover. How can I get it?
Tina

The translated editions are unfortunately not available in the original English. However, as they use content from previous issues of *The MagPi*, you're not missing anything! These versions are for people who perhaps cannot speak English or have difficulty doing so. You can always quickly browse through one and find out which tutorials it uses, though.

Below The translated editions use content from old issues of *The MagPi*, so don't worry about missing anything!

Learning through games

I was reading Matt Richardson's article 'Creating to learn' in the latest *MagPi* magazine and thought to drop a line.

I learned programming over 30 years ago as a teenager when computers (and also gaming) were considered for nerds and seriously uncool. I started on a Tandy TRS-80 model III and learned MS-DOS batch and BASIC (compiler) programming, and wrote software my parents used for their company and also for some other companies. Some software is still in use today.

A lot has changed since then. Gaming became cool because of, among others, Nintendo and Sony's PlayStation. And the Raspberry Pi has made programming cool. Especially the interaction between code, the internet, and real-life components like LED, LCDs, speakers, sensors, motors, robotic parts, etc. makes it interesting for many more people, also young ones.

For the last 25 years I didn't do much programming, except for some maintenance. But the Raspberry Pi (and Arduino) got me interested in building some projects again.

I started with this one: DIY arcade cabinet – Raspberry Pi running RetroPie, then followed that with a DIY photo booth powered by a Raspberry Pi (inspired by an article in *The MagPi*).

Recently I built an Arduino-powered stereo VU meter and yesterday I built an Arduino date, time, and temperature LED matrix display.

Now, getting to the point of this message: I didn't know anything about programming in Python or C (Arduino Sketch) before these projects. Neither was I interested in it – why should I learn it? However, I needed to write code for the last three projects.

So having an idea and being focused on wanting the project to get finished makes you dig into it, do research, learn, make mistakes, fix them, and finish and enjoy the end result. It is very rewarding having turned an idea into reality all by yourself.

So hats off to the Raspberry Pi project and the people and companies who encourage us all to create – keep up the good work!

Eric

Thanks for the kind words, Eric! We're always happy when people get excited with what they can do with code and a few components, whatever their experience level or age is! Huge kudos on your own projects as well.

FROM THE FORUM: RECYCLING MAGPIS

Is there a way to pass old copies of the magazine onto a school, or code club? Seems a shame to just bin/recycle them.

richard238

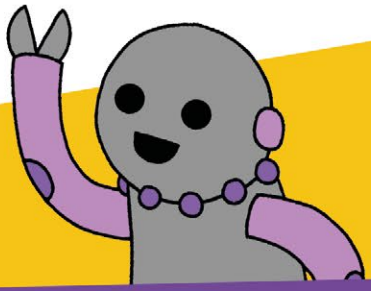
We don't currently have a system for this, but perhaps we should! If you have any old issues of *The MagPi* you want to give away, drop Rob a line at **rob.zwetsloot@raspberrypi.org** or tweet **@TheMagP1** and we'll try to see if we can find them a good home where they'd be needed.

The Raspberry Pi Forum is a hotbed of conversations and problem-solving for the community.
Join in via **raspberrypi.org/forums**

WRITE TO US

Have you got something you'd like to say?
Get in touch via **magpi@raspberrypi.org** or on The MagPi section of the forum at: **raspberrypi.org/forums**

{code club}



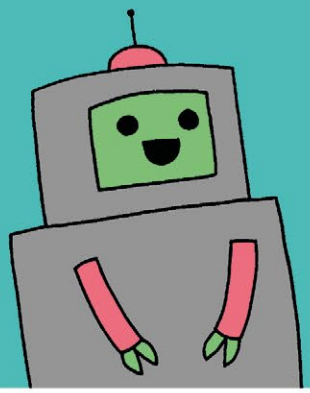
START A CODE CLUB IN YOUR SCHOOL!

Code Club is a network of volunteers and educators who run free coding clubs for young people aged 9-13.

Our aim is to inspire the next generation to get excited about computer science and digital making.

"We use Code Club's fun educational resources to run a weekly after-school club for Year 7 and Year 8 pupils. The students benefit considerably from the extra challenge!"

Karen Dadd, Computing Teacher



- **Code Club is free**
- **Code Club provides step-by-step guides for Scratch, Python, HTML, and Sonic Pi**
- **Code Club helps children develop skills including logical thinking, creativity, and resilience**

We have over 6000 clubs across the UK teaching more than 80,000 young people to code—come and join us!"

Find out more at www.codeclub.org.uk

Code Club is part of the Raspberry Pi Foundation. Registered Charity Number 1129409

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- 5 × Flick HAT Zeros

All of these are courtesy of Pi Supply (**pi-supply.com**).

For a chance to win one of these great Flick HAT and Case kits, you just need to go online and enter our competition. You could be one of the lucky winners!

Learn how to use the Flick HAT 3D to control a robot arm with hand gestures magpi.cc/2hGAn9Q

Enter now at magpi.cc/WinNov17

Terms & Conditions

Competition opens on 25 October and closes on 30 November 2017. Prize is offered to participants worldwide aged 13 or over, except employees of the Raspberry Pi Foundation, the prize supplier, their families or friends. Winners will be notified by email no more than 30 days after the competition closes. By entering the competition, the winner consents to any publicity generated from the competition, in print and online. Participants agree to receive occasional newsletters from The MagPi magazine. We don't like spam: participants' details will remain strictly confidential and won't be shared with third parties. Prizes are non-negotiable and no cash alternative will be offered. This promotion is in no way sponsored, endorsed or administered by, or associated with, Instagram or Facebook.

MATT RICHARDSON

Matt Richardson is the Executive Director of the Raspberry Pi Foundation North America and author of *Getting Started with Raspberry Pi*. Contact him on Twitter @**MattRichardson**.

GAMING AS A GATEWAY

Matt Richardson's take on how gaming leads to learning

As you'll see from the cover story of this issue of *The MagPi*, the Raspberry Pi makes a great computer for gaming projects. In fact, I would guess that setting up a Raspberry Pi for retro gaming is one of the most popular ways for people outside of the maker community to use our affordable credit card-sized computer.

A whole generation of young computer gamers has grown up into adulthood. And while we've come a long way, going from Frogger to Fallout 4, there's a strong feeling of nostalgia for classic retro games these days. Couple this nostalgia with higher levels of comfort with computer technology among the masses and you can understand why gaming with Raspberry Pi is so popular right now.

GAME PI

This presents a great opportunity for our Raspberry Pi community to grow. A person may purchase a Raspberry Pi because they want to play a few games from their childhood. Going through the process of setting up their Raspberry Pi-based game console, that person may well learn a little bit about computers. Maybe they'll also see all the other possible things they can create with Raspberry Pi. Hopefully the experience will spark the curiosity about how else their Raspberry Pi can be used, not only for entertainment, but also for utility. For the mainstream public, I see gaming with Raspberry Pi as a gateway to all the possibilities that the product, the resources, and the community have to offer.

This is nothing new. Gaming and computing have gone hand-in-hand since the early days of computers. And ever since those early days, gaming has been a great motivation for people to learn about computers. Whether you're setting up a Raspberry Pi for retro gaming, speccing out a high-performance gaming tower, or writing code to develop your own game, there's a lot of ways that an interest in video gaming can lead to more serious learning about technology.

I suspect that most of the people who work today as video game developers started with a passion for games as opposed to a passion for the technology alone. I especially admire the work of video game developers because they require more than just technical chops. Creating a video game is a wonderful blend of technology, storytelling, user experience, music, sound effects, character development, art, design, and performance. Video games have a wonderful blend of creativity and technology that I absolutely love.

At the Raspberry Pi Foundation, we're particularly interested in helping young people understand that computers intersect with many different disciplines, subjects, industries, interests, and passions. In other words, they don't have to be interested in computers themselves in order to use them in a way that is meaningful to them.

Empowering youngsters to create their own games is an especially effective way to inspire them to experiment with technology in a way that's more meaningful to them. Take a look at the learning resources on **raspberrypi.org**. For good reasons, many of them are centred around creating a game in Scratch or Python. And if you visit a CoderDojo, you'll find a common rule: "If you didn't make it, you can't play it." It encourages members to dedicate that time to making their own games to play as opposed to playing games they've downloaded from the internet.

It doesn't matter if you're making games or just playing them for fun. Because there are so many ways that gaming can lead to learning about technology or even a creative career path, the potential upside goes far beyond fun.

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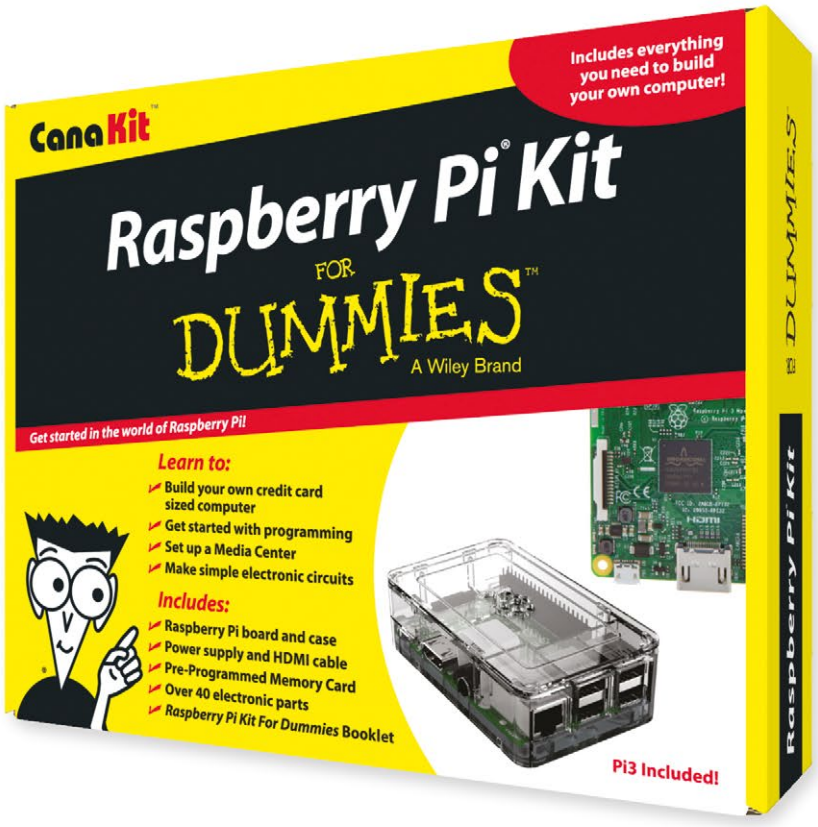

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